Automotive History Review

Winter 2017 Issue Number 57

Alternative Power in Automotive History:

Electric and Compressed Air

The Society of Automotive Historians, Inc.

An Affiliate of the American Historical Association

Letters

While reading *Anders Clausager's* interesting article on the British Horsepower Tax in *AHR 56*, the thought running through my mind was the extent some small capacity six-cylinder engine designs were influenced by this fiscal tax.

This is particularly relevant as Anders pointed out about narrow bores limiting the amount of room for valve sizing and breathing. Assuming a desire to maintain a narrow bore with the same engine capacity between a four- and a six-cylinder engine, the six only compounds the head congestion. Yet you had the likes of high output six-cylinder OHC engines found in MGs such as the Magnette with only 1271 cc. The bore remained narrow at 57 mm with a long stroke of 83 mm. But at the other extreme you had the OHC 4 ½-litre Bentley with a bore and stroke of 99 mm x 140 mm with only four cylinders.

One can understand that if the longer-stroke engines were not as smooth as their short stroke equivalents, the inherent balance of a six would have encouraged the many small-capacity sixes found in the UK. Alternately W. O. Bentley created a durable thumper that did not shake itself to pieces in spite of a capacity of over a litre per piston.

Either way I would appreciate hearing from Anders whether the Horsepower Tax influenced the number of small capacity six-cylinder engines in the UK and if not, what other factors were in effect.

Louis F. Fourie
West Vancouver, BC
Canada

Anders Clausager responds: *It is a while ago that I wrote this article, and it was to some extent based on the argument from my degree dissertation of 1999, but I am delighted to learn that it finally got into print, and I shall look forward to receiving a copy of* AHR 56. *In the article, I did not go into much detail about the so-called "pint-sized" sixes, but I do so in my forthcoming book on Wolseley, since the 1930 Wolseley Hornet was a prominent example.*

Small six-cylinder engines of the 1920s and 1930s were mostly a British phenomenon, but were also occasionally seen in France (Mathis, Renault), Germany (BMW), and Italy (Alfa Romeo, Fiat). A six cylinder engine will typically run more smoothly at low rpm and will have better torque characteristics than a four (especially if aided by a long stroke), so they are more refined and flexible. You can do more driving in top gear and do not have to change gear so often, which I believe was the main reason why they became popular, at least in Britain. With the introduction of flexible engine mountings in the 1930s, four cylinder engine characteristics were effectively improved, and at the same time, gear changing was made easier by synchromesh.

The problem that faced British designers was how to find the best compromise between adding two extra cylinders and the need to keep the bore small because of the horsepower tax, since (as I think I show in the article) for two engines of the same capacity and the same bore/stroke ratio, the six-cylinder will have a higher horsepower rating under the RAC formula than a four-cylinder.

Many of the small sixes in Britain were based on existing eight hp four-cylinder engines with a bore of maximum 57mm (nearly 2.25 inches), and with strokes of between 75mm and 100mm (say 3 to 4 inches), giving capacities of 750cc to 1000cc for the eight hp fours, and thus 1125cc to 1500cc for the corresponding twelve hp sixes. The bore/stroke ratio was typically around 1.5. If the engine was of 57mm by 90mm, capacity would be 918cc for an eight hp four (the Morris Eight) and 1378cc for a twelve hp six (the Morris Ten-Six, or the later Wolseley Hornet). By contrast a four-cylinder engine of 1378cc could be rated at just ten hp, and so would cost 20 per cent less to tax, £10 rather than £12 per year.

continued on page 38

Automotive History Review (ISSN 1056-2729) is a periodic publication of the Society of Automotive Historians, Inc.

Don Keefe, Editor

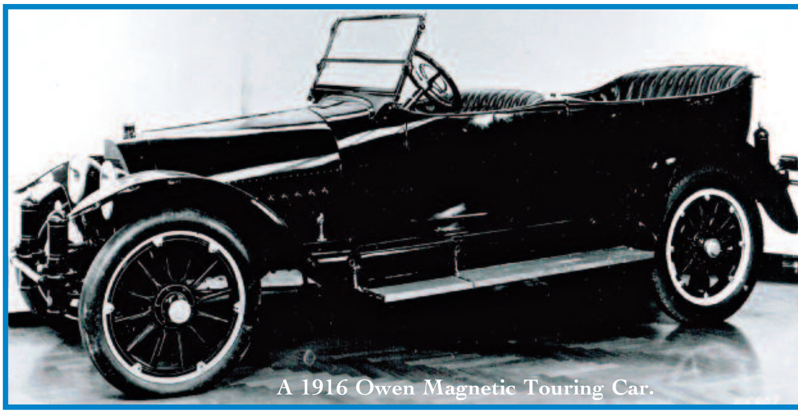
 Correspondence in conjunction with Automotive History Review should be directed to:

Don Keefe, Editor
1448 Seagull Drive, Apt. 312,
Palm Harbor, FL 34685 USA

Further information about the Society may be obtained by writing to The Society of Automotive Historians, Inc., c/o Cornerstone Registration, Ltd., P.O. Box 1715, Maple Grove, MN 55311-6715 USA or at www.autohistory.org.

Automotive History Review

Winter 2017 Issue Number 57



A 1916 Owen Magnetic Touring Car.

CONTENTS

Front Cover: The electric-powered Baker Torpedo Kid (#999) lines up with its contemporaries in 1903. Photo courtesy of the Western Reserve Historical Society.
Back cover: A patent drawing of Alberto Antunes' compressed air-powered automobile, 1910.

The Historic Electric Vehicle Industry:
The Case of Baker and Rauch & Lang

By Robert R. Ebert, Ph.D.

Photography and ads from the author's private collection unless otherwise noted

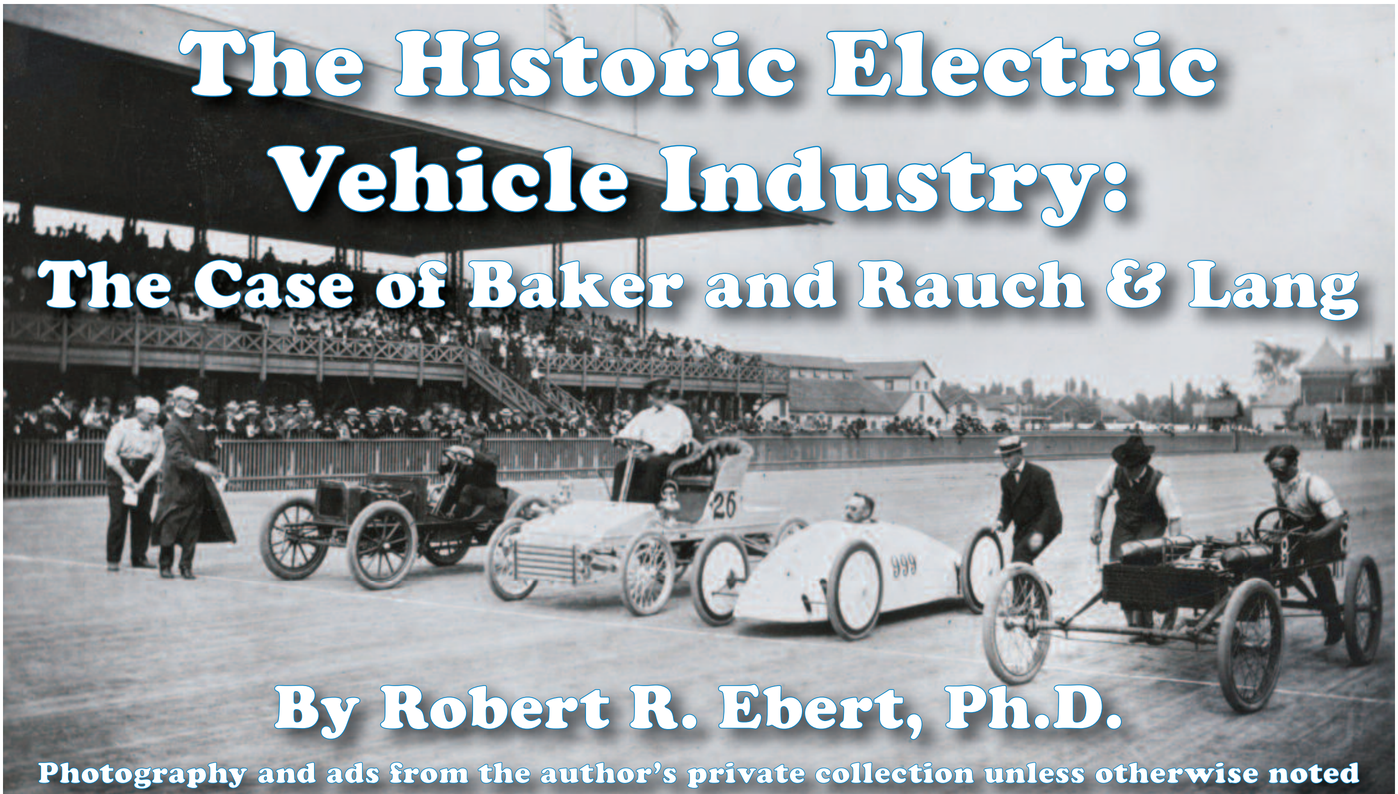


Fig. 1: Looking like it was beamed in from a 1950s-era Bonneville Speed Week, the electric-powered Baker Torpedo Kid (#999) lines up with its contemporaries in 1903. Photo courtesy of the Western Reserve Historical Society.

At the end of the 19th century and beginning of the 20th century it was unclear which type of technology would prevail as the propulsion system for the automobile. Vehicles powered by internal combustion engines competed with vehicles that were steam driven and electrically driven for the attention of the buyers of the so-called "horseless-carriage."

By midway in the first decade of the 20th century, though, the relative position of electric vehicles in the United States automobile industry was becoming clear. United States Census of Manufacturing data in Table 1 show that in 1904 electric vehicles accounted for only 6.57 percent of automobile production in the country. By 1914 that figure had dropped to 4.4 percent and by the end of World War I less than 0.2 percent of the automobiles produced in the U.S. annually were electrically powered. However, in spite of their relatively small share of the automotive market, for about a quarter century the electric vehicle manufacturers competed aggressively with each other and with gasoline and steam–powered vehicles for the attention of consumers.

Among the firms that competed in the electric vehicle industry in those early years were the Baker Motor Vehicle Company and the Rauch & Lang Carriage Company, both of Cleveland, Ohio. Baker and Rauch & Lang were only two of the twelve electric vehicle manufacturers that existed in Cleveland in the 1898 to 1920 period (Wager, 1975). However, within the local Cleveland industry and the broader U.S. electric vehicle industry, which, according to Handy (2006), had an estimated 88 firms prior to 1940, Baker and Rauch & Lang came to occupy significant and at times leading positions.

The experiences of the Baker and the Rauch & Lang firms and their ultimate merger to form the Baker R & L Company (occasionally but not correctly referenced as Baker, Rauch & Lang Company) are the topic of the research presented here. Therefore, the focus of the research is relatively narrow. While some description will be given to the specific products of the firms and how those products evolved through time, the primary emphasis of the research has been on the structure and operations of the two companies individually and then in their merged state. Likewise, existing research on the full scope of the electric vehicle industry by authors such as Kirsch (2000), Mom (2004), and Schiffer (1994) is drawn upon to put the position of the Baker and Rauch & Lang firms into perspective.

One of the constraints in researching the Baker and Rauch & Lang firms is the lack of substantial primary source material on the firms other than product literature. Stock in both Baker and Rauch & Lang was closely held. As a result, regular detailed public disclosure of their finances, including sales and earnings, did not occur. Reported production data, when available, often are of a general and rounded nature. Here, where a few primary sources have been uncovered they are utilized. In the absence of such materials, the technique of getting as close to the primary sources as possible through examination of published contemporary news and similar materials is employed.

The thesis of the examination of the Baker and Rauch & Lang firms is that the nature of the products made by those two firms, individually and, later, in their merged state, was such that long-term survival as automobile manufacturers in the first quarter of the twentieth century was all but precluded. It is argued that the fundamental economics of the automobile industry, the preferences exhibited by consumers, and the lack of supportive infrastructure for electric vehicles contributed to the demise of Baker R & L as a viable automobile maker.

Analysis of the Baker R & L firm begins with profiles of the two firms, Baker and Rauch & Lang, individually, as independent firms prior to their merger. The analysis will then proceed to discuss the purpose and effects of the merger, the competitive conditions confronted by the Baker R & L Company, and its response to the way in which the automobile industry was evolving by the end of the second decade of the 20th century. Summary timeline histories of the firms are shown in Tables 2 and 3.

Table 1: Automobile Production in the United States, 1904, 1909, 1914, 1919

Product	1919		1914		1909		1904	
	Number	Value in $ Millions	Number	Value in $ Millions	Number	Value in $ Millions	Number	Value in $ Millions
Automobiles Totals	1,678,926	1,547.0	568,781	458.8	126,593	164.3	21,692	23.8
Gasoline & Steam Power	1,675,892	1540.7	564,112	448.7	122,767	127.0	20,267	21.3
Electric Power	3,034	6.2	4,669	10.0	3,826	7.3	1,425	2.5
Electric Percent of Total	*0.18%*	*0.40%*	*0.82%*	*2.18%*	*3.0%*	*4.44%*	*6.57%*	*10.5%*

Source: *Bureau of the Census, Abstract of the Census of Manufacturers, 1914 and Abstract of the Census of Manufacturers, 1919.*

The Baker Motor Vehicle Company

Walter C. Baker was born in 1867 in Hindsdale, New Hampshire and moved to Cleveland, Ohio with his parents in 1871. His father, George W. Baker, with Thomas W. White and Rollin C. White (the Whites were not related), developed a sewing machine and organized the White Manufacturing Company, parent of the White Sewing Machine Company, in Cleveland (Sommerlad). Rollin White later developed both steam and gasoline powered automobiles that led to the creation of the

Table 2: The Baker Motor Vehicle Company–A Profile

1897: Walter Baker built an electric automobile.
1898: Baker Motor Vehicle Company was founded and an electric buggy was launched.
1899: Two-passenger Runabout produced. Thomas Edison bought the second one produced.
1900: Baker Motor Vehicle Company moved to a new factory on East 69th Street in Cleveland from its original factory on East 65th Street.
1902: Walter Baker appeared in fatal speed trials with the aerodynamic electric Torpedo.
1903: Walter Baker crashed the new Torpedo Kid electric racer, ending his racing career.
1905: Baker had sales of 400 cars.
1906: A new Baker plant on W. 80th Street in Cleveland was completed. Production totaled 800 units in 1906 and the firm advertised it was "the largest electric vehicle maker in the world."
1907: Baker started a light truck department.
1909: Baker put shaft drive into all of its models.
1910: Baker claimed sales of 1,000 cars. Also, Baker opened a new sales and service branch at E. 71st Street and Euclid Avenue in Cleveland in what was then the most fashionable and exclusive part of Euclid Avenue.
1912: A Police Patrol Wagon was added to the Baker line.
1913: Steering wheels were made optional on Bakers. Tiller steering had been standard.
1915: Baker merged with Rauch & Lang Carriage Company to form Baker R & L Co. Also, the R. M. Owen Company of New York, manufacturer of the Owen Magnetic automobile, was purchased.
1916: The Baker name was retired for passenger cars.
Sources: Mom, G. (1904). The Electric Vehicle; Baker 1898-1915, http://earlyelectric.com/carcompanies.html; Wager, R. (1975). Golden Wheels; Poor's Manual of Industrials, 1916.

White Motor Company (Wager, pp. 53 and 205).

After graduating from Case School of Applied Science (now Case Institute of Technology of Case Western Reserve University), Walter Baker worked for the White Sewing Machine Company and one of its subsidiaries, the Cleveland Machine Screw Company. While at the latter firm, Baker became interested in the development of steel ball bearings, an interest that he maintained throughout his life. In 1895, Baker formed the American Ball Bearing Company which, in time, made axles and other parts for automobile manufacturers such as Cadillac, Packard, Pierce Arrow, Lozier, Peerless, Ford, and Mercer (Wager, p. 205).

In 1897, Walter Baker and Frederick C. Dorn, treasurer of American Ball Bearing Company, experimented with the building of an electric automobile. Their success led to the organization of the Baker Motor Vehicle Company in 1898 with Dorn as president and Baker as vice president and mechanical engineer. In time, though, Baker's primary interest continued to be in the ball bearing industry and he relinquished his official positions at the Baker Motor Vehicle Company in 1906, although he maintained a financial interest in the firm (Wager, pp. 205-206).

Before leaving active management of the Baker Motor Vehicle Company, however, Walter Baker made a number of important contributions to the development of the company. He oversaw the establishment of the firm's first factory on East 65th Street in Cleveland, then its move to a new plant on East 69th Street in 1900, and ultimately to the company's permanent location in 1906 on West 80th Street at Baker Avenue on Cleveland's west side (*Cleveland Plain Dealer*, 1978).

In its 1908 catalog, Baker boasted that the West 80th Street factory was largest in America devoted to building electric cars. In 1910 the Baker Motor Vehicle Company established a luxurious corporate showroom at East 71st Street and Euclid Avenue (O'Malley, B1).

The first Baker automobile was an electric buggy with a ¾-horsepower motor and batteries with ten cells and chain drive to the rear axle. Baker claimed a driving radius of 20 miles for the car on good roads and favorable conditions. In the process of developing the electric car and its reliability, Walter Baker and Thomas Edison became friends which resulted in Edison becoming among the first to buy a Baker Electric car (Wager, p. 206).

Among the innovations that Walter Baker introduced in his early cars was a shaft drive that replaced the chain drive in transmitting power from the motor to the wheels. The first rear axle bevel gear was shown by Baker at the first automobile show in Madison Square Garden in New York City in November 1900 (Wager, p. 206). Baker advertising in 1911 reported that the company began putting shaft drive in some of its production cars in 1903 and that by 1909 chain drive had been completely abandoned. In 1909, the *New York Times* reported that nearly all gasoline automobile manufacturers had abandoned chain drives in favor of the bevel shaft drive because of its simplicity, cleanliness, and absence of lost motion and gave credit to Baker for having invented the feature (*New York Times,* November 28, 1909, p. S4). Baker ads in the 1911-1912 era frequently had the statement "The car that brought them all to Shaft-Drive."

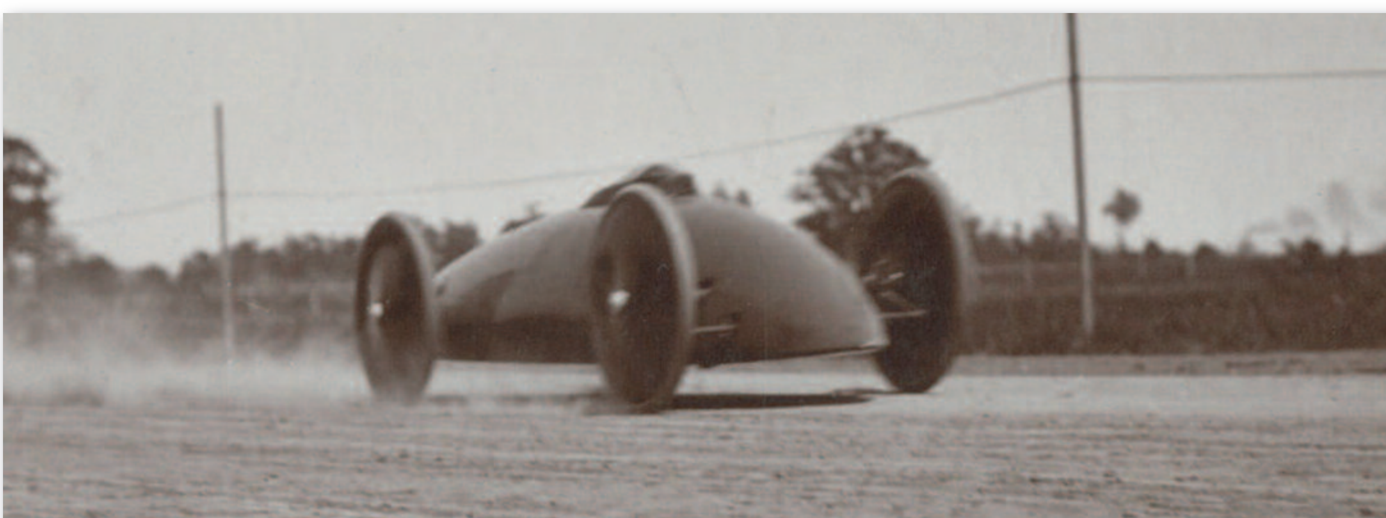


Fig. 2: The 1902 Baker Torpedo at speed. Photo courtesy of the Western Reserve Historical Society.

Table 3: The Rauch & Lang Carriage Company/Baker R. & L.–A Profile

1853: Jacob Rauch opened a blacksmith shop on Columbus Road in Cleveland.

1860: Jacob's son, Charles, opened a second shop on Pearl St. (later named West 25th Street) in Cleveland. Carriages and wagons now were made from the two shops.

1884: Charles E. J. Lang, a local real estate investor, became a partner in what became the Rauch & Lang Carriage Company. A four story factory was leased on Pearl Road.

1904: Prototype Rauch & Lang electric automobile was built.

1905: First production year for Rauch & Lang electric cars with 50 being built.

1908: Rauch & Lang built about 800 cars.

1909: Rauch & Lang production reached about 1000 electric automobiles. The Rauch & Lang factory doubled its capacity. The salesroom was at 627 Superior Avenue in Cleveland.

1912: Production declined to an estimated 600 cars, about half equipped with a new Rauch & Lang feature, worm drive.

1914: Rauch & Lang introduced bevel gear transmission on some cars in place of worm drive. Also offered were choices of lever or wheel steering.

1915: Rauch & Lang Carriage Company merged with Baker Motor Vehicle Company to form Baker R & L Company. The company also built the Owen Magnetic automobile. Company products sometimes are incorrectly referred to as Baker-Raulangs, although both Baker and Rauch & Lang cars were being built.

1916: The last year for Baker automobiles. The Rauch & Lang models were continued.

1919: Baker R & L built about 700 cars and was making closed bodies for other automobile manufacturers. The company was reorganized into two divisions – one making electric industrial trucks and the other making auto bodies.

1920: Baker R & L electric car business sold to the Steven-Duryea Company of Chicopee Falls, Massachusetts, which continued limited production of the Rauch & Lang automobiles until the late 1920s.

Sources: Mom, G. (1904). The Electric Vehicle; Baker 1898-1915, http://earlyelectric.com/carcompanies.html; Wager, R. (1975). Golden Wheels; Poor's Manual of Industrials, 1916.; Coachbuilt; http://www.coachbuilt.com/bui/b/baker_raulang/baker_raulang.htm

The Baker Shaft Drive innovation resulted in both imitation and the accusation of patent infringement by other automobile manufacturers. Baker General Manager Fred R. White attributed the development of the Shaft Drive to the firm's chief engineer, Emil Gruenfeldt. In comments made in 1911 regarding a patent infringement suit that Baker filed in several United States courts in September 1909 against a number of competitors, White said: "Several of these competitors are now offering shaft-driven constructions which do not closely imitate the epoch marking work of Gruenfeldt; but others have quite recently so closely imitated our various models that the layman can hardly distinguish the pioneer from the pirate" (*The Plain Dealer*, September 10, 1911, p. 14). Among the firms sued was Rauch & Lang and speculation exists that the merger of Baker and Rauch & Lang in 1915 was, at least in part, to settle the allegations of patent infringement (See, for example, http://earlyelectric.com/carcompanies.html).

In its early years, as the Baker Motor Vehicle Company electric automobile business developed, Walter Baker engaged in activities that were designed to promote the product. For a short time building electric racing cars was an important part of that product–promotion activity. In 1902, Baker designed an electric racer with a twelve horsepower Elwell-Parker Motor that had an angle iron frame with a light torpedo-shaped superstructure of wood and canvas. Electricity to power the racer was furnished by 40 cells of Gould light-weight, lead-zinc accumulators organized into eight crates in the 3000 pound vehicle named The Torpedo (Fig. 2). At an Automobile Club of America speed trial on Staten Island on Memorial Day, 1902, the racer covered the first six-tenths of a mile in 36 seconds, but then went out of control on the uneven roadbed and plunged into the crowd. Although the two occupants of the racer were unhurt, unfortunately, two spectators were killed and a half dozen others seriously injured (*Scientific American*, June 14, 1902).

In 1903, Walter Baker again attempted to set a speed record with The Torpedo Kid (Fig. 1), a single–seat electric race car powered by a ¾-horsepower electric motor of the same type used in production Baker electrics of that time. In September 1903, Baker drove The Torpedo Kid (with number 999) to record-breaking speeds for two to ten mile distances at Cleveland's Glenville Track. However, in races for electric cars later in the day he crashed into a Waverly Electric auto. That ended Baker's

Table 4: Baker, Rauch & Lang Electric Automobiles Price Data: Representative Years and Models

Make and Model	1900-1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
Baker Victoria					$3,000	$3,000		$2,000	$2,000	$2,000	$2,000							
Baker Coupe						$3,000		$2,000	$2,700	$2,700	$2,800	$2,800	$2,600					
Baker Roadster						$2,500	$2,500			$2,500		$2,300	$2,300					
Baker Brougham				$3,500	$3,000	$4,000		$3,500	$3,500	$3,100	$3,100	$3,100	$3,250					
Baker Runabout	$850	$1,200	$1,200	$1,200	$1,800		$1,850	$2,000	$2,000									
Baker Stanhope	$1,600	$1,200	$1,600	$1,600	$1,600	$1,600	$1,000	$1,000	$1,000									
Rauch & Lang Stanhope (swb)			$1,800	$1,800	$1,850	$1,850	$1,850	$1,900	$1,900	$2,100								
Rauch & Lang Coupe			$2,000	$2,000	$2,100	$2,100	$2,100	$2,100	$2,100	$2,400				$2,475				
Rauch & Lang Victoria						$3,200	$3,200	$2,200	$2,200	$2,450								
Rauch & Lang Landaulet										$3,000								
Rauch & Lang Roadster										$2,600	$2,600	$2,600	$2,600	$2,600	$2,600	$2,600		
Rauch & Lang Coach										$3,800	$3,100	$3,150	$3,100	$2,900	$2,900	$2,900	$3,600	
Rauch & Lang Brougham						$4,000	$4,000			$2,900	$2,900	$2,950	$2,950	$3,000	$2,800	$2,800	$3,350	$3,700
Rauch & Lang Town Car Limo													$4,000	$4,000	$4,000	$4,000		
Rauch & Lang Stanhope (lwb)					$1,850					$2,350								
Baker R & L Roadster														$2,600				
Baker R & L Coach														$2,900	$3,000			
Baker R & L Town Car														$4,000				
Baker R & L Coupe														$2,475				
Baker R & L Brougham														$3,000	$2,800			

Prices listed are factory prices. Baker, Rauch & Lang/Baker-Raulang– Although these designations occasionally were used in the trade press following the merger of Baker and Rauch & Lang companies of Cleveland, Ohio during the summer of 1915, the cars to which they referred were more properly designated under their individual names as Baker and Rauch & Lang.

Sources: *Electric Vehicles*. November 1917, pp. 137-139 and Kimes, Beverly Rae and Clark, Henry Austin, Jr., *Standard Catalog of American Cars 1805-1942*, Krause Publications, pp. 98-100 and 1264-1267.

racing career (Kimes and Clark, p. 97).

One of the ongoing challenges for Baker, and other electric automobile manufacturers, was to demonstrate that an adequate number of miles driven could be obtained from one charge of the batteries. For example, on May 23, 1907, Emil Gruenfeldt of the Baker Company, accompanied by a reporter for the *Cleveland Leader* newspaper, drove a standard Baker Victoria for 9 hours and 20 minutes over a 101.6 mile system of Cleveland streets on a single battery charge (*Cleveland Plain Dealer*, May 26, 1907, p. 3). Three years later, on November 9, 1910, Gruenfeldt drove another Baker Victoria electric to a then world record of 244.5 miles on a single charge of the batteries. The total running time for that test was 19 hours and 20 minutes with an average speed of 12.65 miles per hour on a rainy day (*New York Times*, December 11, 1910, p. C8).

Richard Wager notes that, while impressive, these demonstrations of extended mileage on a charged battery were significant exaggerations of what the typical electric car owner could expect. Most electric auto owners were obtaining only a fraction of that kind of mileage on a battery charge (Wager, p. 212).

The objective of demonstrating the range of its products was the hope that such demonstrations would help Baker sell more vehicles. Precise and consistent data on

Baker unit sales and production are difficult to obtain for reasons explained earlier. Data that are available indicate that in its early years Baker did succeed in increasing its output at a significant rate. In 1905 Baker claimed to have produced about 400 automobiles. The following year, when its new plant on West 80th Street in Cleveland was finished and operating, output was approximately 800 units (Wager, p. 208). On May 19, 1907, *The Cleveland Plain Dealer,* in reporting that Baker had built and shipped a record-breaking 84 of its electric autos in the month of April, stated: "[that number of shipments] is certainly phenomenal and places The Baker Company well up in the ranks of the largest shippers of automobiles in the country."

In the company's later years of auto production the *Moody's Manual of Railroad and Corporation Securities* for 1914 stated that Baker's production capacity was six cars per day and annual production was 1,500 units (Moody's Industrials, 1914, p. 103). That estimate was consistent with *Poor's Manual of Industrials* estimate of Baker's annual production being in the range of 1,200 to 1,500 units (*Poor's Manual of Industrials*,1914, p. 133). To put these data into perspective, it is important to note that Baker was one of the major electric vehicle manufacturers in the second decade of the twentieth century. Even if these estimates of its production are accurate, Baker was a very small firm in the context of the whole United States auto industry at that time (see Table 1).

Given these production estimates for Baker output, the occurrence of a rumor in 1912 that the company was discontinuing the production of pleasure cars became somewhat disconcerting to the firm. On September 1, 1912, the *Cleveland Plain Dealer* reported that the rumor was of unknown origin and had "absolutely no basis in fact." Officials of the company called the rumor false (*Cleveland Plain Dealer*, September 1, 1912, p. 11A).

In addition to the automobiles Baker had a line of commercial electric trucks. It is possible that the Baker promotion of its commercial vehicles led to the speculation that it was going to abandon the pleasure automobile segment of the electric vehicle industry. The commercial vehicle market appears to have been significant for Baker. In 1910 Baker exhibited three commercial vehicles at the Madison Square Garden Show in New York. These models consisted of chassis for 1000, 2000, and 4000 pound wagons. It was claimed that each of the models had a carrying capacity 25 to 50 percent greater than the rated capacity (*New York Times*, January 16, 1910, p. S4).

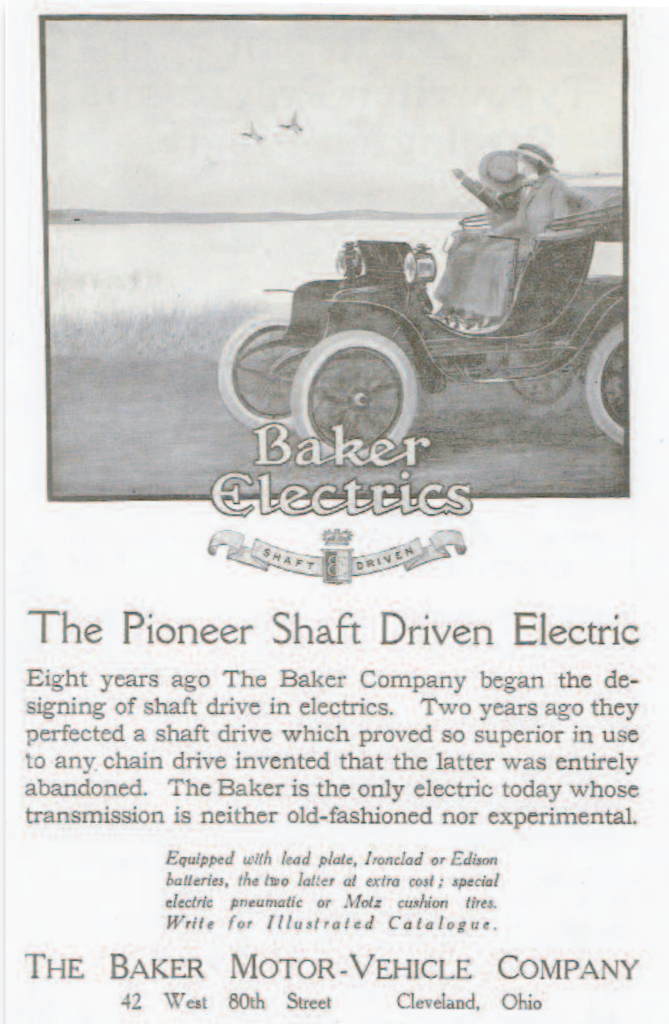


Fig. 3: A print ad for the shaft-driven 1911 Baker Electric.

In January 1912, Baker was one of seven makers of commercial electric vehicles to exhibit products at the Madison Square Garden Show. In promotional materials for that event, Baker claimed that its electric trucks were particularly well suited to, and compared favorably with horses for, short-haul work in cities having considerable traffic congestion (*The New York Times*, January 14, 1912, p. XXI). The Baker trucks were in use by over 200 companies by 1912 (Wager, p. 212).

In 1917, the post-merger Baker R & L firm turned its Baker truck building attentions to vehicles for the military during World War I. Among the products built for the war effort by Baker were bomb handler industrial trucks and load-carrying trucks. These were trucks useful

Fig. 4: A print ad for the 1911 Baker Electric touted its ease of operation in all weather situations.

on military and industrial sites, but not for major troop or freight carrying activities. Following the war Baker industrial truck production was continued and through the years provided an important market for the firm after it had ceased building electric automobiles (Wager, p. 217).

Beyond the direct war effort, the traditional commercial electric truck market was not aided by World War I. In 1919 electric trucks accounted for less than 1 percent of the total commercial vehicles produced in the United States compared to 11 percent in 1909. The decline in the relative position of electric trucks was attributed to low gasoline prices in the United States which, particularly during the war, gave an advantage to the gasoline – powered trucks. The effect was to increase the scale of production and lower the prices of gasoline trucks in the U.S. (Kirsch, pp. 164-165). One of the effects of this development was that, given the type of trucks built by Baker during the war, the firm became established in and had a post-war advantage in the more limited niche market for electric industrial trucks used at industrial sites and in factories.

Producing electric vehicles is one challenge but selling them is another. Later in this article overall competitive issues that confronted the electric vehicle industry and Baker R & L will be covered in some detail. Here, though, some generalities that were evident in the advertising for electric autos are discussed in the context of Baker advertising.

Kirsch has noted that electric autos often were viewed as fashionable ladies' cars that offered social distinction (Kirsch, p. 101). Figure 3, for example, shows an April 29, 1911 Baker ad from *The Literary Digest* that promotes the advantages of the firm's shaft drive. However, the illustration in the ad is of a Baker electric having both a passenger and driver that are nicely dressed women. Figure 4 shows two women elegantly dressed for winter weather about to enter a Baker Electric during a snow storm. The text in that ad from the December 23, 1911 issue of *The Literary Digest* leaves little to the imagination about the market being cultivated: "Women enjoy driving an electric as graceful and as easily handled as the Baker." Likewise, Figure 5 shows a Baker ad from the January 1912 issue of *Country Life* magazine. In the Figure 5 ad the text states "Its [the Baker's] social prestige is not confined to the National Capital; it is nation wide." From this ad there is little doubt as to the market Baker was cultivating.

At a minimum, the Baker automobiles, by virtue of their price (see Table 4) and by the nature of the firm's advertising, were aimed at an exclusive market. In particular, the company appears to have recognized that an important component of that market was wealthier societal women as portrayed in the accompanying ads.

The Rauch & Lang Carriage Company

Rauch & Lang came to the electric vehicle market somewhat later than did Baker. Whereas Baker was building and selling electric automobiles by 1899, Rauch & Lang did not enter the electric automobile market until 1905. The Rauch & Lang firm, though, by the time it began building electric cars, had a half century of experience in building horse-drawn carriages and wagons. Thus, the name of the firm was The Rauch & Lang Carriage Company.

In 1853, Jacob Rauch, an immigrant from Bavaria, opened what he called his "Wayside Smithy" shop on

Columbus Road on Cleveland's west side. The shop did the usual blacksmith activities such as shoeing of horses and repairing wagon wheels and buggies. In time, Jacob expanded his blacksmithing activities to include the actual building of wagons. His son, Charles, then just eight years old, on occasion helped him in the shop (Love, p. 76).

By 1860, Charles began to take an active role in the business which, by then, was building both carriages and wagons. In 1860 the firm opened a second shop on Pearl Road in Cleveland (later renamed West 25th Street). His father, Jacob, was killed during the Civil War at the Battle of Gettysburg in 1863 after which Charles closed the original shop. The firm expanded from wagon production to the making of complete coaches and carriages in the newer factory (Baker, Rauch & Lang, Baker-Raulang, www.coachbuilt.com). By the late 1870s the Rauch carriages were dominant in the Ohio and surrounding market. To expand further, Charles E. J. Lang, a Cleveland real estate businessman, was brought into the business and by 1884 the firm was incorporated and called the Rauch & Lang Carriage Company (Wager, pp. 213-214).

Very early on, Rauch & Lang established a reputation for making carriages and buggies that were of the highest quality. In an era when low-cost buggies could be bought elsewhere for $50 to $75, Rauch & Lang was able to charge $275 for its buggies. For carriages of a standard kind that were priced around $1000 in the general market, Rauch & Lang was able to charge as much as $1500. The Rauch & Lang carriages were known for their style and superior craftsmanship. Each Rauch & Lang carriage carried a number which indicated the individual artisan who worked on it which was an incentive for that worker to give the carriage a particularly personal touch of originality and style (Love, p. 76).

By the middle of the first decade of the 20th century Rauch & Lang began to realize that there would be a future in the manufacture of automobiles. After some experimenting that began in 1903, the firm decided to build electrics and completed its first car in 1904. Actual production of electric Rauch & Lang automobiles began in 1905. From the start of its automobile building era Rauch & Lang electrics continued the company's carriage-making tradition by making vehicles that were of the highest quality and beautiful design (Wager, p. 215).

Fig. 5: A print ad boasting of the shaft-driven 1912 Baker Electric's prestigious position in Washington Society.

When Rauch & Lang entered the automobile industry its factory had expanded through its carriage and wagon-making days and encompassed several buildings at 2180 West 25th Street. The firm also had a downtown showroom on Superior Avenue in Cleveland and by 1908 was able to list sales agencies for its electric cars in twenty cities throughout the United States. Rauch and Lang production expanded quickly in its early years in the auto industry. Output was 50 cars in 1905 and expanded to about 500 cars in 1908 when the company claimed it had orders for 300 more. In 1909 the firm increased its production capability to 1000 units. Although it increased its production capacity, Rauch & Lang was still a craft and limited production firm. It took pride in the fact that ninety days were required to finish a Rauch & Lang body. Twenty-four coats of paint and varnish combined with hand rubbing were applied to each car (Wager, pp. 214-215).

Although detailed financial information on the close-

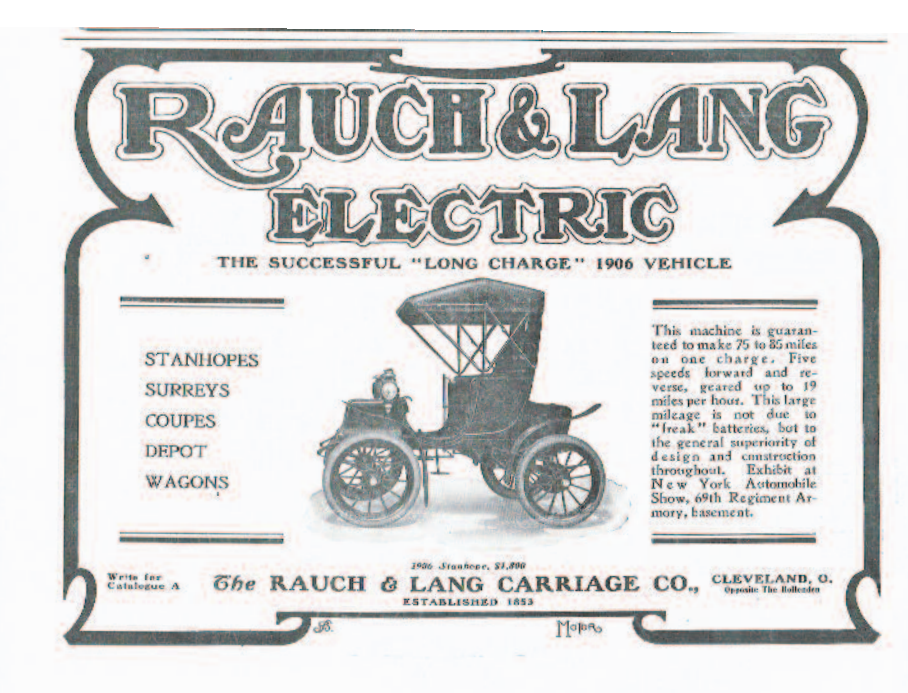


Fig. 6: A print ad for the 1906 Rauch & Lang Electric.

ly held Rauch & Lang company is not available, it is apparent that it expanded financially as its production capabilities increased. In 1907, its capital stock was increased from $75,000 to $250,000 and then to $1 million in 1909 (Wager, p. 215). The increase in capitalization of Rauch & Lang appears to have been a result of investment by Charles L. K. Wieber, president of the Lakewood Realty Company in suburban Cleveland, a firm associated with the Charles Lang family (Baker, Rauch & Lang, Baker-Raulang, www.coachbuilt.com).

Following the recapitalization of Rauch & Lang in 1907 the Hertner Electric Company, which was supplying components to Rauch & Lang, became a part of the firm. John H. Hertner and the Hertner firm's chief engineer, D. C. Cunningham, were put in charge of the Rauch & Lang electric vehicle division enabling most of the auto firm's components to be manufactured inhouse. At the top executive level of Rauch & Lang significant changes occurred in 1912 upon the death of Charles Rauch. Charles Wieber was elected President and General Manager and Charles Lang was made vice president and treasurer (Baker, Rauch & Lang, Baker-Raulang, www.coachbuilt.com).

Even in its first couple of years of electric auto production, Rauch & Lang was aware of customer concerns about the range of electric vehicles. In a January 1906 ad in *Motor* magazine it was claimed the Rauch & Lang Electric was a successful "Long Charge" vehicle capable of making 75 to 85 miles on one charge. In retrospect, one can only comment that the claim appeared optimistic at best.

Through the 1911 model year, according to its advertising, Rauch & Lang offered its customers a choice between shaft or enclosed chain drive. (That shaft drive offered by Rauch & Lang may have been the cause of the lawsuit by Baker discussed earlier.) In 1912 Rauch & Lang produced about 600 units and introduced its worm drive. In worm drive the worm and gear were mounted in a single casing and adjusted to the axle. A Rauch & Lang-Hertner high-speed motor was used with the worm drive. Rauch & Lang claimed at the time that its worm drive would improve the efficiency, economy, and long life of electric cars (*Electric Vehicles*, July 1913, p. 119). About half of its 1912 production was equipped with the worm drive.

The worm drive was replaced in some of the 1914 Rauch & Lang production by a bevel gear transmission. Also offered in 1914 was a choice of steering arrangements. The driver of a Rauch & Lang could choose to operate the vehicle from the front seat, from the back seat, from both positions or even by a wheel in the front seat only. If steering from the back seat was used the front seat could be turned to face the back of the car. An interesting part of the Rauch & Lang product development is that the steering wheel option was discontinued in 1915 after being offered for only a single year (Wager, p. 215).

The automotive market at which Rauch & Lang electric automobiles was aimed becomes quite clear from the pricing of its cars and the advertising of the firm. Table 4 shows a list of some of the models offered by Rauch & Lang through the years along with their prices. In an era of Model T level pricing, the Rauch & Lang offerings were quite expensive, even reaching the $4000 level in some years. The company made no apologies for its pricing. Figure 7 shows the Rauch & Lang ad from the December 1913 issue of *Cosmopolitan* magazine. The text of the ad contains the following: "The Rauch & Lang is the highest-priced Electric on the market. Its value is readily apparent to those who seek a car of artistic and mechanical perfection." The theme of quality and luxury is seen throughout Rauch & Lang advertising. The ad entitled "Quality," shown as Figure 8, from the February 8, 1917 issue of *Life* magazine, emphasizes the quality issue and concludes that the Rauch & Lang; "…is a luxurious treasure–beautiful, simple, desirable, silent and safe."

Rauch & Lang enjoyed initial success as an electric automobile manufacturer. By 1910 it was not unusual for the firm to be producing in the range of 500 to 600 units a year. That was very low production by gasoline auto manufacturer standards, but caused the company to claim that it was one of the largest electric vehicle manufacturers in the world, and possibly the largest (*Cleveland Plain Dealer*, January 23, 1910, p. 22). Output was large enough to encourage Rauch & Lang to build onto its factory in Cleveland with a four story addition of 78,000 square feet in 1913 ("Rauch & Lang Enlarging Factory," *Electric Vehicles*, July 1913, p.108). Electric auto production in the United States was increasing in that period of Rauch & Lang expansion but was to peak in about 1914 (see Table 1). The owners and management of Rauch & Lang Carriage Company and the Baker Motor Vehicle Company seemed to sense that the electric vehicle market was peaking and that future growth would be difficult. Those concerns brought the two companies together in 1915.

The Baker R & L Company

"If the interests of the Baker and the Rauch & Lang companies were joined…their output would be larger than that of any other electric auto factory in the world" is the way the *Cleveland Plain Dealer*, in a page 1 story on June 5, 1915, characterized as rumor, plans to merge the two large Cleveland electric automobile manufacturers. The article went on to point out that Baker produced both electric pleasure cars and commercial trucks while Rauch & Lang produced only pleasure cars.

The next day, June 6, 1915, that same newspaper in a page Three-B article reported that the merger of Baker Motor Vehicle Company and the Rauch & Lang Carriage Company, both of Cleveland, was a done deal. The name of the new electric vehicle manufacturer was The

Fig. 7: A 1913 print ad for the Rauch & Lang electric car introduced the new, innovative worm-drive system.

Baker R&L Co. Officers of the newly created company were President, Charles L.F. Wieber, previously president of the former Rauch & Lang Carriage Company; First Vice President, Fred R. White, previously first vice president and general manager of Baker; Second Vice President, Charles E. J. Lang, previously vice president and treasurer of Rauch & Lang; Counsel and Attorney, George H. Kelly, previously secretary of Rauch & Lang.

The official announcement of the merger of Baker and Rauch & Lang stated very clearly and directly what the purpose of the merger was: "The consolidation was formed primarily to secure the dominating position in the electric vehicle industry; secondly, to build a dealer's organization of exceptional strength; thirdly to eliminate duplication of models; fourthly to eliminate duplication of advertising and sales expense" (*Electric Vehicles*, July 1915, pp. 3-4). The *Electric Vehicles* magazine article went on to state that consolidation of the product line was a primary goal of the merger.

Although both the Baker and Rauch & Lang product lines were to be continued, the Baker line was to special-

Fig. 8: A rare color print ad for the 1917 Rauch & Lang Electric.

ize in the promotion of the worm gear coupe which, at that time, sold for $2475 and was known as the Light Weight Coupe. It had a wheelbase of 90 inches, worm gear, was available with a horizontal control lever or steering wheel (both operated from the left rear seat) and had a 32-cell battery system. The Rauch & Lang models would continue to provide roomy vehicles catering to customers desiring a "high-class electric limousine" (*Electric Vehicles*, July 1915, pp 3-4).

The products of the merged firm are sometimes referred to as Baker-Raulang electrics. The Baker-Raulang designation is misleading and not consistent with the products of the firm which always were separate and bore their individual nameplates Baker or Rauch & Lang. There never was a vehicle produced with a Baker-Raulang nameplate (Wager, pp. 217). Legally, the way the firm is referenced in advertisements and financial documents is Baker R & L Company.

At the time of the merger in 1915, The Baker Motor Vehicle Company was capitalized at $1,250,000 and claimed a daily production capacity of six cars and annual production capacity of 1,500 vehicles (Moody's, 1914, p. 103). Rauch & Lang Carriage Company went into the merger capitalized at $1,000,000 (Wager, pp. 217). After the merger the Baker R & L capitalization was $5,000,000 in common stock and $750,000 cumulative preferred stock. Actual outstanding was $2,499,700 in common and $493,700 in preferred stock. The combined production capacity of Baker R & L was stated in the financial press as 15 cars per day and an annual production capacity of 3,000 units (*Moody's* 1916, pp. 2364). Those data suggest that the pre-merger capacity of Rauch & Lang had been nine units per day.

Post-merger Baker R & L continued to be closely held which meant that detailed financial information, including profit and loss statements, was not published or made generally available. However, in the fall of 1915 the General Electric Company became attracted to and invested in and acquired three seats on the board of directors of Baker R & L. The involvement of General Electric was associated with Baker R & L undertaking the manufacture of the Owen Magnetic car, a topic discussed in the next section of this article (*Electric Vehicles*, February 1916, pp. 60).

Following the merger Baker R & L continued making the individual Baker and Rauch & Lang cars. The 1916 Baker coupe with a 90-inch wheelbase was the same in appearance as the 1915 model but had an increase in length from 120 to 126 inches. The Rauch & Lang Model J6 had its wheelbase decreased from 102 inches to 100 inches and claimed a top speed of 26 miles per hour (Wager, pp. 217). The strategy of separating the Baker and Rauch & Lang lines of electric cars was carried over into some of the advertising of Baker R & L. Figure 9 is an advertisement in the July 1915 issue of *Electric Vehicles* magazine for Rauch & Lang Electrics and Baker Electrics, listed as two separate makes, by a Chicago dealer shortly after the merger of the two firms.

During 1917, Baker R & L focused on production for the World War I effort as discussed earlier. That wartime effort included making shells and bomb handlers as well as some load-carrying trucks for the U.S. military (Wager, 217). Some production of Rauch & Lang electric coaches was possible during the war. For 1918 the company catalog, entitled "The Logical Car of Today With a

Fig. 9: A print ad from The McDuffee Automobile Company, a Chicago-area dealer of the era, showcasing both Baker and Rauch & Lang Electric cars.

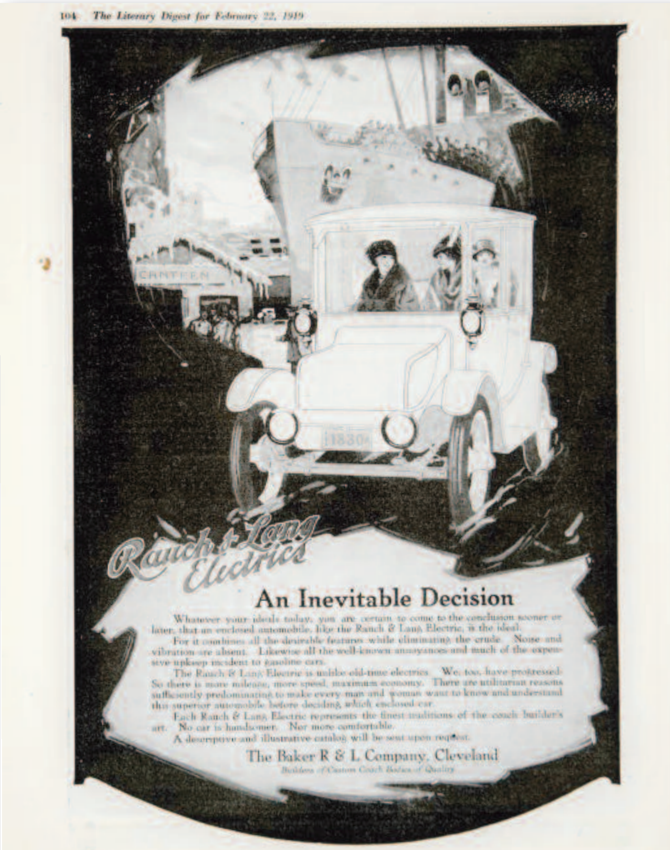


Fig. 10: A print ad for the 1919 Rauch & Lang Electric entitled "An Inevitable Decision," which appeared in the February 22, 1919 issue of *The Literary Digest*.

History of the War 1914-1918," promoted the cars as a logical choice for the postwar period when a car essential for city and suburban use would be needed. The catalog featured two Rauch & Lang models, the Brougham Model B-26 with a 92-inch wheelbase and a Coach Model C-35 with a 102-inch wheelbase. The data in Table 4 indicate that the Rauch & Lang Brougham price actually decreased from 1916 to 1918 while the prices of other models remained constant. Prices did rise substantially in the postwar market in 1919 and 1920.

The 1916 model year was the last year for the Baker Electric Automobile. While the Baker name was attached to numerous industrial vehicles for several more decades, no longer was there a Baker electric car. The dropping of the Baker line reflected changes that were going on in the automobile industry in general and in the electric vehicle industry in particular.

Data in Table 1 show that a major contraction occurred in the electric automobile market between 1914 and 1919 in a period when the overall automobile market was having substantial growth. The electric vehicle market had not been a major factor in the auto industry for a decade by the end of World War I. In 1919 the total number of electric automobiles produced was equal to what Baker R & L alone could have built. Data that are available suggest that in 1919 Baker R & L produced about 700 units which was less than a quarter of its estimated capacity of 3,000 units (Wager pp. 217). That amount of production gave Baker R & L a significant 23 percent of the market (using Table 1 data for total electric auto industry production). Although significant, it was a large share of a declining market.

In spite of the optimism displayed in the process of Baker and Rauch & Lang merging in 1915, it is evident that the merger involved a strategy for survival for the company. In the end, there was not enough room for both the Baker product line and the Rauch & Lang product line to survive in the evolving electric automobile market. Although the Rauch & Lang models were viewed as somewhat upscale from the Baker line, an analysis of the price data in Table 4 suggests that the two makes were participating in the upper end of the automobile market in general. Product placement with relatively high prices and a contracting electric automobile market combined to make it an understandable strategy to drop the Baker line.

Figure 10, an advertisement in the February 22, 1919 issue of *Literary Digest*, shows how the efforts of the company now were focused on the Rauch & Lang name, even though "Baker" continued as part of the corporate logo. Note that the 1919 ad continued the marketing strategy of emphasizing the appeal of electric cars to women.

The year 1915 was important for Baker and Rauch & Lang with its merger to form the Baker R & L Company. However, the firm became engaged in another interesting and challenging enterprise during that year. In 1915 the production of the Owen Magnetic automobile became part of the operations of Baker R & L.

The Owen Magnetic Experience

The February 1916 issue of *Electric Vehicles* magazine carried the announcement that a consolidation of the Owen Magnetic Company of New York City and the Baker R & L Company of Cleveland had been completed. Production of the Owen Magnetic automobile was moved from New York to the Baker factory in Cleveland in December 1915. The Rauch & Lang factory in

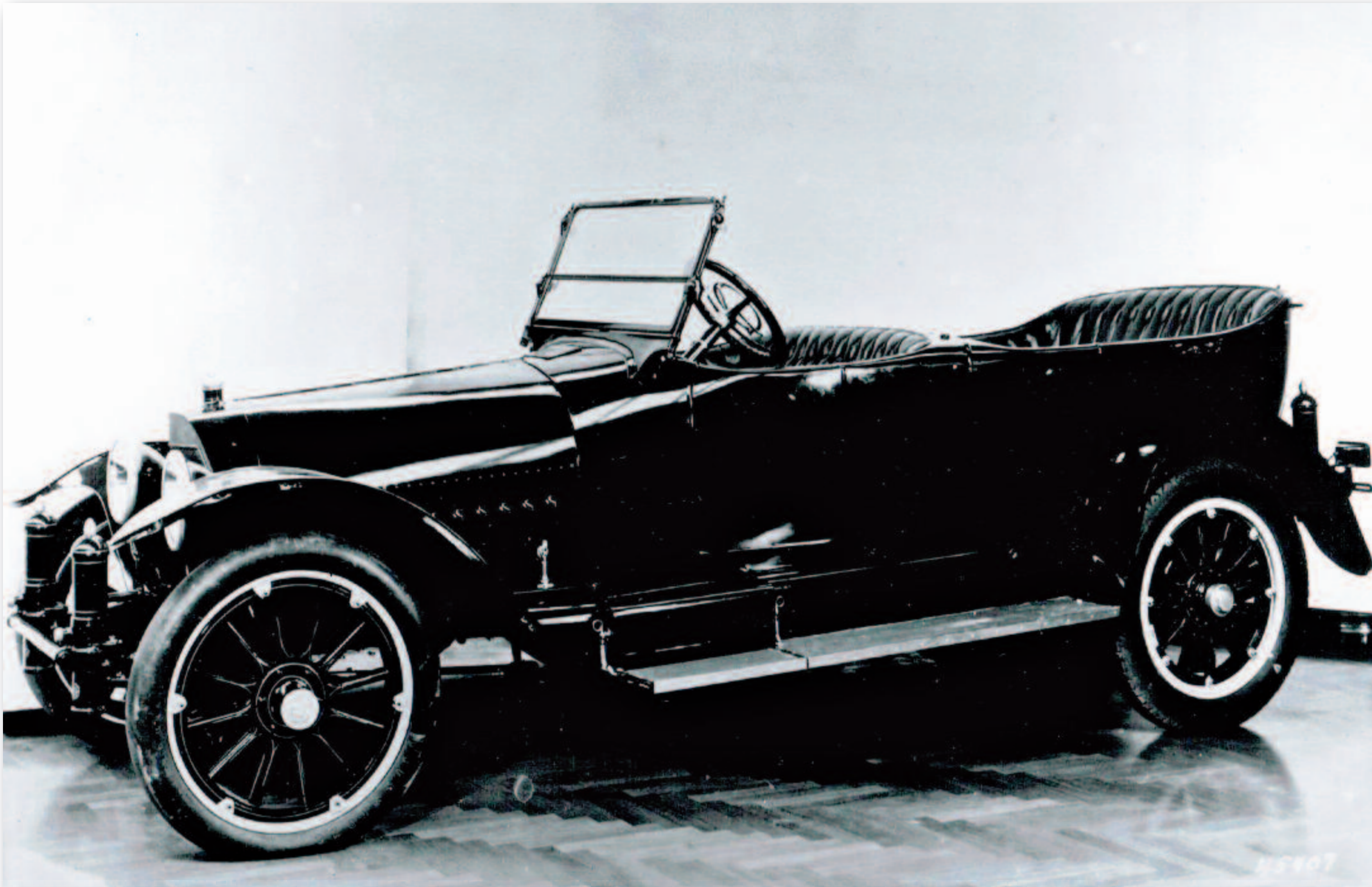


Fig. 11: 1916 Owen Magnetic Touring Car.

Cleveland was then used for the building of bodies for the Owen Magnetic in addition to the manufacture of Baker R & L electric cars (*Electric Vehicles*, February 1916, 60).

Justin B. Entz, an electrical engineer, had patented a design in the 1890s for a power plant in which a gasoline engine drove a generator which provided electricity transmitted over an air gap to an electric motor which provided power to wheels. In 1898 and 1899 some Columbia automobiles built by the Pope Manufacturing Company of Hartford, Connecticut, had electric transmissions designed by Entz. Use of the Entz patents was obtained by Raymond M. Owen and ultimately incorporated in the Owen Magnetic automobile (Wager, 143). In 1912, after making refinements to the Entz principles, Walter C. Baker built some experimental models of a gasoline-electric car and bought the Entz patents (*Electric Vehicles*, February 1916, 60).

At the January 1915 New York Automobile Show the R. M. Owen Company of New York displayed the new Owen Magnetic touring car. The Owen Magnetic featured rakish sloping lines and a six-cylinder gasoline engine which turned a generator which in turn powered an electric motor. Advertised as the "Car of a Thousand Speeds," any number of speeds could be obtained through a control lever on the steering wheel. There were no gears to shift with those functions and those of the nonexistent clutch, flywheel, magneto, and starter motor performed by parts in the transmission. The output of Owen Magnetic automobiles in 1915 was about 250 units with that production being under license from Baker which held the patents (Wager, 143).

The merger that created the Baker R & L Company also included the R. M. Owen Company. Raymond Owen then became a vice-president of the Baker R & L firm. With that consolidation came the involvement of the General Electric Company which had acquired an interest in Owen Magnetic and Entz patents. With the Owen Magnetic now part of Baker R & L, General Electric took an investment position in Baker R & L and named three members to the Baker R & L Board of Directors. Those directors representing the General Electric interests were Anson W. Burchard, Vice President of General Electric and D. C. Durland and

Richard W. Swartout (*Electric Vehicles*, February 1916, 60).

General Electric had a specific interest in hoping that the Owen Magnetic automobile would be a commercial success. The GE factory in Fort Wayne, Indiana, had been tooled to manufacture the electric units for Owen Magnetic cars as well as similar units for other firms that might have been licensed under the Entz patents (*Electric Vehicles*, February 1916, 60).

The Owen Magnetic automobiles were designed and priced in the luxury class. The first model shown at the 1915 New York Auto Show was a five-passenger touring car with a 126 inch wheelbase and a price of $3,300. A 1916 four-passenger sport touring Owen Magnetic with a Holbrook body was priced at $6,000. Later models such as those for 1918 had wheelbases from 128 inches to 142 inches and were priced from $5,475 to $6,500 (Wager, 143 – 145). In 1919, the future of the Owen Magnetic became part of major changes at the Baker R & L Company.

Baker R & L Departure from Automotive Production

The data in Table 1 show the decline in the demand for electric automobiles in the United States as the second decade of the 20th century was coming to an end. As the electric vehicle industry contracted the production levels and fortunes of the Baker R & L Company, with annual output of an estimated 700 units, were not evolving as had been hoped at the time of the consolidation in 1915. As a result, the firm undertook another major reorganization which led to its departure from the production of automobiles.

In 1919, Baker R & L was reorganized into two divisions. One division was for the manufacture of industrial trucks and the other was for the building of automobile bodies (Wager, 217). At the executive level, in January 1919, Charles C. F. Wieber became chairman of the board and Frederick R. White became president. Named a vice-president and general manager was E. J. Bartlett. No longer part of the management and board were two vice-presidents, Raymond M. Owen and Charles E. J. Lang (Coachbuilt).

As part of the reorganization, Raymond Owen was given the right to build the Owen Magnetic car on his own. Manufacture under Owen was relocated to Wilkes-Barre, Pennsylvania. Approximately 200 Owen Magnetic cars were built in Wilkes-Barre before the firm went bankrupt in 1921 (*Coachbuilt*). Total production of Owen Magnetics at the Cleveland plant is estimated to have been about 700 cars (Wager, 145).

The passenger automobile manufacturing activities of Baker R & L underwent a major change of ownership and location in January 1920. The manufacture of Rauch & Lang Electrics was absorbed into the Stevens-Duryea Company of Chicopee Falls, Massachusetts. The Stevens-Duryea subsidiary was named Rauch & Lang, Inc. A new factory was erected adjacent to the Stevens-Duryea plant to build the electric cars, which no longer were made in Cleveland. While primarily a Stevens-Duryea operation, Baker R & L maintained some interest in the new Rauch & Lang, Inc. with E. J. Bartlett, the Baker R & L general manager, on the board of the new firm. The Baker R & L factory on West 80th Street in Cleveland, which had been making the electric cars, was converted to the building of bodies for cars and the making of industrial trucks and tractors designed for use in industrial plants. (*Cleveland Plain Dealer*, January 18, 1920, 105). Output of Rauch & Lang automobiles in Massachusetts, including a small number of electric taxi cabs, was very limited and ended by the late 1920s (Coachbuilt; and Wager, 217).

In Cleveland, the former Baker R & L Company underwent a name change to the Baker-Raulang Company. For a number of years it continued building automobile bodies for Packard, Franklin, Hupmobile, Reo, Chandler, Peerless, and Duesenberg as well as some bus bodies for White, Reo, and General Motors. Conversion of the auto body division to the building of commercial and utility vehicle bodies occurred in 1935 and continued until 1948 (Wager, 217-218).

As a builder of industrial trucks, the Baker-Raulang Company continued until 1954 when it became a subsidiary of the Otis Elevator Company called Baker Industrial Trucks. Later it became known as the Material Handling Division of Otis making such items as industrial fork-lifts (Wager, 218). In 1977 Otis sold Baker-Raulang to Linde AG, a major producer of material handling equipment. In 1999 Linde changed the name of its Baker Material Handling Corporation to Linde Lift Truck Corporation (Kion). Linde no longer makes products in the former Baker factory in Cleveland. Linde Material Handling North America is located in Summerville, South Carolina, and is part of the Kion Group North America which manufactures a broad line of material handling equipment and pays tribute to its Baker history on its web site (Kion).

The noted changes in the activities of the former Baker R & L Company were associated with its departure from the production of electric automobiles by 1920. That raises the question of what competitive and market conditions were in the electric vehicle industry in the post World War I period that led to the changes at Baker R & L. While not the primary focus of this paper, a survey level discussion is now undertaken of the electric vehicle infrastructure and competitive challenges that confronted Baker R & L in its last years as an electric automobile producer.

The Electric Vehicle Infrastructure Challenge

The perennial challenge faced by all electric vehicle manufacturers in the early 20th century was the need to assure owners of electric cars that adequate resources were available for charging the batteries of their cars. David Kirsch, in *The Electric Vehicle and the Burden of History*, Michael Schiffer in *The Electric Automobile in America, Taking Charge*, and Gijs Mom in *The Electric Vehicle, Technology and Expectations in the Automobile Age* have included comprehensive discussions on the charging of electric vehicles and the availability of charging resources. Here only a brief survey of that issue is undertaken.

The challenge of having adequate charging facilities for the electric vehicles was a result of a very basic engineering reality at the time. The electric car was a direct current machine, but alternating current had become the standard electrical supply. Therefore, a charging station equipped with some type of rectifier was needed to charge an electric vehicle (*Electric Vehicles*, March 1917, 93-94).

Home charging systems for electric cars were available in a number of different configurations. Schiffer has pointed out, however, that using these systems tended to be somewhat complex and difficult. Because of those challenges, many electric car owners preferred to leave the charging of the batteries of their cars to professionals (Schiffer, 63-64). It was these circumstances that led some electric utility companies to offer electric car battery charging services from their central station charging facilities. Not all electric companies, however, were convinced that providing the charging service to electric car owners on a convenient basis would result in profitable operations, even though the charging usually could be done at night which made use of off-peak capacity for electric companies (*Electric Vehicles*, March 1917, 93-94).

The matter was presented quite succinctly by Dr. C. P. Steinmetz of General Electric before a convention of the National Electric Light Association in 1914 where he concluded that: “the most feasible way for charging electric vehicles is a central station where the auto owner runs his car into the garage of the central station in the evening and overnight the charge is made or completed…and the next morning the machine goes out freshly charged” (*Electric Vehicles*, July 1914, 10). As late as March 1917, *Electric Vehicles* magazine observed that without central stations providing these services, the electric car was helpless. The result was that electric car manufacturers were confronted with the dual challenge of convincing the public to buy electric cars *and* convincing the central stations to take care of the public when electric cars were purchased (*Electric Vehicles*, March 1917, 93-94).

Compounding the problem of charging electric cars was an initial lack of standardization of the charging infrastructure of the vehicles among the various manufacturers. In 1910, for example, at least eight different types of charging plugs were in general use because the electric vehicle manufacturers were installing plugs of their own design. In 1912, at the third convention of the Electric Vehicle Association of America, two standard designs for charging plugs were adopted by the industry–one for passenger vehicles and one for commercial vehicles (Kirsch, 105).

Although a complete discussion of the role of the Electric Vehicle Association of America (EVAA) would take us beyond the scope of this article, some mention of its functions within the electric vehicle industry is in order. The EVAA was founded in September 1910. It was the conception of Arthur Williams, a central station manager for the New York Edison Company. Initially, the EVAA had 29 members but by 1913 could claim membership of 380 manufacturers of electric vehicles, storage batteries, and accessories as well as managers and owners of central stations (*Electric Vehicles*, May 1913, 1-3).

Over the years, among the objectives of the EVAA was closer cooperation between central stations and other phases of the electric vehicle industry. One of its specific recommendations was that every central station should have an electric vehicles department and establish better charging facilities (*Electric Vehicles*, November 1915, 161).

A change occurred in the functioning of the EVAA in 1916 when it became part of the National Electric Light Association (NELA). *Electric Vehicles* magazine observed that the EVAA had been preponderantly an organization of central stations which provided 58 percent of its funding (*Electric Vehicles*, March 1916, 91). In reflecting on the absorption of EVAA into NELA, *Electric Vehicles* magazine stated the following:

> The conventions of the NELA are attended by thousands of central station representatives….a great many of these men, as well as the companies they represent, are not at all interested in the electric vehicle; and some of them are positively prejudiced against it…The electric vehicle organization, now affiliated with their society, will meet them and exert its direct influence upon them for the first time in the history of the industry. The central station is one of the fundamentals of the electric vehicle business. The latter, indeed, cannot achieve success without the support of the former. It is to the central station's financial advantage to encourage the use of electrics; and the only reason for such indifference as it has manifested is its multiplicity of other interests (*Electric Vehicles*, April-May 1916, 135).

In assessing the impact and influence of the EVAA on the electric vehicle industry, Kirsch notes that in the first half of the second decade of the 20th century the electric vehicle industry did, in fact, enjoy substantial growth (see Table 1, for example). Only in comparison to the spectacular growth of the internal combustion powered automobile does the experience of the electric vehicle industry in those years look anemic. Kirsch goes on to argue that it took the central stations a very long time to awaken to the potential of the electric vehicle to their businesses. The central stations folks had organized the Electric Vehicle and Central Station Association of America (EVCSA) in 1909 which then evolved into the EVAA in 1910. Had the central stations people begun cooperation with the electric vehicle industry a decade earlier, Kirsch suggests that a more robust sphere for the electric vehicle might have been established in the automotive industry (Kirsch, 94-95, 126–128).

The charging facilities issue was of concern to the electric vehicle makers including Baker and Rauch & Lang. In a February 1916 article in *Electric Vehicles* magazine, George H. Kelley, Secretary of Baker R & L, was very clear about the problem of battery service and other service facilities available to electric car owners. He stated: "We must admit to ourselves that an electric car is not able to get the care…that a gas car can secure today…battery care and battery service has been the great big problem in electric vehicles." In that article Kelley expressed appreciation to the New York Edison Company for its establishment of a big garage in New York City which was giving service to electric car owners and relieved the electric car manufacturers of some of the responsibility for routine service. Kelley observed that as a result of the establishment of the Edison Company garage "our salesmen have been able to go out and attempt to sell a car, and spend all of the time selling cars instead of stand idly by attempting to make excuses to customers" (*Electric Vehicles*, February 1916, 57-58).

Thus, one of the key elements in attracting customers to their product for electric vehicle manufacturers, including Baker R & L, was the availability of service, particularly charging facilities. The challenge of adequate charging and service facilities never completely was resolved and must be concluded to have been one of the factors that caused the ultimate decline in the electric vehicle industry.

The Challenge of Competitors of Baker R & L

The issue of adequate charging facilities was one of the factors creating a struggle for Baker R & L through the years, both as separate companies (Baker Electric and Rauch & Lang) and then later in their merged state. A second challenge came from the competitors of Baker R & L in the electric vehicle industry. While estimates (and definitions of successful entry) may differ among sources, a credible estimate was one by G. Handy that 88 firms had attempted entry into the manufacture of electric vehicles. (Wager lists a dozen made in the Baker hometown of Cleveland alone.) Discussion of that many firms would be beyond the scope of the research presented here. However, a brief discussion of two key competitors of Baker R & L will be helpful in assessing the position of that firm in the industry. Those two competitors were Detroit Electrics and Milburn Electrics.

Detroit Electrics

"The Detroit Electric" was the brand name given to automobiles and trucks built by the Anderson Electric Car Company of Detroit, Michigan. William Anderson headed the Anderson Carriage Company which had been building horse-drawn carriages since 1884. In 1907, Anderson, working with George M. Bacon, an electrical engineer, introduced an electric carriage to the market (Schiffer, 116).

With the maturing of the electric vehicle industry in the 1915–1916 era, Anderson purchased some of its competitors. The Chicago Electric Motor Car Company, which entered the electric pleasure car market in 1912, was purchased by the Walker Vehicle Company in 1915. Walker, a subsidiary of the Commonwealth Edison Company of Chicago, had been involved in the manufacture of electric commercial vehicles. Acquisition of the Chicago line expanded the firm into the pleasure car business (*Electric Vehicles*, January 1915, 11). The Walker involvement with pleasure vehicles ended in late 1916 when it decided to once again concentrate only on commercial vehicles and sold the Chicago Electric car business to the Anderson Electric Car Company. Anderson sold the inventory of Chicago Electrics that it inherited and discontinued the line. The purchase of Chicago Electric was engineered by D. E. Whipple, Central District Manager for the Detroit Electric vehicle. The motivation for the purchase of Chicago Electric was clear with Whipple's statement that elimination of the Chicago Electric from the marketplace would lead to increased success for Detroit Electric (*Electric Vehicles*, November 1916, 153).

In contrast to Baker and Rauch & Lang which seldom advertised prices of their cars, Detroit Electric was aggressive in portraying its products as relative bargains for electric car purchasers. Figure 12 has an example of advertising for the 1914 line of Detroit Electrics from the


September 27, 1913 THE LITERARY DIGEST 339

THE Detroit ELECTRIC 1914

With Worm Gear Axle
5-pass. Brougham, Detroit Duplex Drive $3000
4-pass. Brougham, Rear Seat Drive 2850
Gentleman's Roadster 2500

With Bevel Gear Axle
5-pass. Brougham, Front Seat Drive $2800
4-pass. Brougham, Rear Seat Drive 2550
Victoria 2300

All enclosed bodies are of our celebrated "Clear Vision" type. Seats are so arranged that no one sits in front of the driver.

Model 48 Detroit Duplex Drive

Big Volume - Finer Quality - Lower Prices

This is the Detroit Electric policy for 1914—to make ***more*** cars and therefore ***better*** cars than have ever been made by an electric manufacturer; to sell these cars for ***lower*** prices than have ever been asked before; to take only a small profit on ***each*** car, relying on ***large*** volume for an adequate yearly earning.

We believe that this new policy is something people have been waiting for, that it marks a big step forward in the electric car business. We believe it means that thousands of people will buy electrics who have not bought before.

Our Output—Two to One

In the past twelve months we have sold ***more than twice as many cars*** as any other maker of electric pleasure vehicles.

Our factory and service organizations have grown to be the largest in the world devoted exclusively to electric cars. Our manufacturing facilities have been brought to maximum efficiency.

So we have determined to go after even larger volume, to reduce our prices, but at the same time to put into our cars the very utmost in quality. And our 1914 models are the result.

Why Our Prices Are Lower

Every one of the six models listed above, if priced according to the usual methods of figuring, would sell for $300 to $400 more.

Take the worm gear Detroit Duplex Drive car, $3000. The factory cost of this car, plus the ***usual*** rate of profit, would make the list price $3350.

Take the bevel gear Forward Drive Brougham, $2800. Last season's corresponding model sold for $3000. We have added $140 ***actual factory cost,*** in new features and finer quality—and yet we ask only $2800. And so all through the line.

How Quantity Produces Quality

Bear in mind that the reduction in the prices of Detroit Electric cars means no reduction in the quality. Exactly the opposite.

The large volume that makes possible these lower prices also makes possible the highest quality in materials, in workmanship, in improved features.

It requires ***quantity*** to produce ***quality***. The old idea that small production means better quality, more care, finer attention to detail is a fallacy. When a maker builds 1800 to 2000 cars, his standard of quality is higher than when he builds the average output of 400 to 500 cars.

The large manufacturer can afford to have a higher standard. He can and does put better workmanship into his cars—because he can afford the mechanical equipment necessary.

Small production means near-accurate handwork, instead of absolutely accurate machine work. It means steel castings instead of the stronger drop forgings. It means fitting and filing instead of standardized, uniform parts.

Don't Let High List Prices Blind You

The high prices asked for many cars are not evidence of quality. You don't make anything in buying an overpriced car. A few hundred dollars added to the price ***and then taken off again*** by a cut in price or an excessive allowance for a used car, doesn't change the quality of the car. Price doesn't really mean anything except in relation to value.

Detroit Electric cars are lower in price than any cars even approaching them in quality. They are sold at ***catalog prices.*** They are marketed with a smaller discount to the dealer than other cars.

Please see these cars at our dealer's. You will find him to be the most substantial electric car dealer in your city. 1914 advance catalog sent on request.

Anderson Electric Car Company, Detroit, Mich.

Fig. 12: A 1914 Detroit Electric ad from the September 27, 1913 issue of *The Literary Digest*.

Literary Digest. Over the years, Detroit Electric became even more aggressive in its pricing when it announced that the 1917 Detroit Electric three-passenger Cabriolet would have a price reduction of $500 from $2,275 in 1916 to $1,775 in 1917. The company attributed the lowering of prices to its expanding volume of production and, thereby, its ability to purchase large amounts of materials at quantity discounts (*Electric Vehicles*, September 1916, 77-78).

Its strategy of pricing Detroit Electrics very competitively and planning for expanded production proved successful for Anderson, at least in terms relative to the electric vehicle market. Estimates of Detroit Electric production are that in 1907, Anderson built 125 Detroit Electrics, in 1908 output increased to about 400 units, in 1909 to 650, and to 1600 by 1910 (Mom, 118). Data in the *Automotive News 100 Year Almanac*, published in 1996, estimated sales of Detroit Electrics were as high as 1,848 units in 1916, but declined thereafter to 537 in 1920 and 136 in 1925. Production of Detroit Electrics continued on a very limited basis after the mid-1920s. In 1930 output of Detroit Electrics became reduced to indi-

Fig. 13: A print ad for the 1916 Milburn Light Electric touted the marque's low price, something that was not typical of electric vehicle manufacturers. Most were targeted to upscale buyers.

vidual orders with its bodies being obtained from the Willys-Overland Company of Toledo, Ohio. Output on that individual basis continued into 1938 (Wakefield, 228). One estimate for Detroit Electric output was that a total of 13,862 units were produced during the history of the firm (Sinsabaugh, 156). The name of the firm making the Detroit Electric was the Anderson Carriage Company from 1907 through 1910. In 1911 the name of the firm was changed to the Anderson Electric Car Company and then changed again in 1918 to the Detroit Electric Car Company (Wakefield, 229).

Milburn Electrics

A late entrant into the electric vehicle industry was the Milburn Wagon Company of Toledo, Ohio, which had been a coach building firm founded in 1848 by George Milburn, who had emigrated from England to Canada and then to the United States. Originally located in Mishawaka, Indiana, the Milburn firm moved to Toledo, Ohio in 1873 (Milburn Light Electrics, 2008). In September 1914 the company began building a light electric automobile for the 1915 model year that was a quick success in the market with an estimated 2,500 units sold in the first two years (Mom, 257–258).

One of the market challenges that electric auto makers faced was to improve the pleasure of owning an electric car by making the process of charging the batteries more convenient. Milburn was one of the electric car manufacturers that installed a battery swap procedure for its cars in which the discharged set of batteries could be removed and a charged set swapped or installed quickly. Milburn claimed that for its cars a battery swap could be accomplished in two and a half minutes (Schiffer, 162). The Milburn used by the Secret Service under President Woodrow Wilson was designed with that type of a charging system. The battery set was placed on rollers so that the discharged batteries could be rolled out and the freshly charged batteries rolled into the car (Mom, 257–258).

In its advertising, Milburn made the claim that the lightness of the car enabled it to travel faster and obtain more miles per charge than other electric cars. The firm also claimed that in spite of the lightness of the Milburn causing a general lightening of electric cars by competitors, the Milburn was "still by far the lightest" (see Figure 13).

One of the factors leading to the rapid success of the Milburn Electrics was the aggressive pricing that the firm used. Figure 13 shows an ad from the February 26, 1916 issue of *The Literary Digest* for the Milburn Light Electric light electric coupe priced at $1485. Milburn also had a roadster priced as low as $1285 in 1916 (Schiffer, 158). The aggressive pricing made Milburn a worthy competitor for both the Detroit Electric and Baker R & L. One estimate is that about 4,000 Milburns were built during the 1914 to 1923 period (Milburn Light Electrics, 2008).

In 1919, the Milburn plant was destroyed by fire. Production was continued in a building at the University of Toledo. By 1920, the principal business for Milburn was building automobile bodies, largely for Oldsmobile. Only about a fourth of its 800-person work force was engaged in electric car production. In early 1923 General Motors purchased the Milburn plant, but then found it was not needed and sold it later in the year. Milburn's remaining operations, primarily building electric trucks on demand, were moved to a smaller location but operations ceased in 1924. A firm known as Dura, which may originally have been a Milburn subsidiary, was organized in about 1913 and built a variety of mechanical and electrical parts for automobiles into the 21st century although the Toledo factory was closed in 1980 (Milburn Light Electrics, 2008).

Conclusion

The thesis of the examination of the Baker and Rauch & Lang firms has been that the nature of the products made by those two firms, individually and, later, in their merged state, was such that long-term survival as automobile manufacturers in the first quarter of the twentieth century was all but precluded. It is argued that the fundamental economics of the automobile industry, the preferences exhibited by consumers, and the lack of supportive infrastructure for electric vehicles contributed to the demise of Baker R & L as a viable automobile maker.

The discussion presented here of the experience of the Baker and Rauch & Lang firms as independent electric automobile manufacturers and then as a merged Baker R & L Company leads to an acceptance and confirmation of the thesis. During their time in the electric automobile and commercial vehicle industry, the Baker and Rauch & Lang products were respected and well-built and reliable. However, there were internal factors within the electric vehicle industry, societal trends, technical issues, and pricing issues that combined to make it virtually impossible for Baker R & L to survive as a viable automobile manufacturer.

Throughout the history of the firm, before and after the merger, the Baker R & L passenger cars were built using methods that were closely related to the building of horse-drawn carriages. Baker R & L and its competitors built vehicles of outstanding quality, but not on a true production line or mass-production basis. It was an era when the assembly line methods of production were quickly being adopted by the makers of gasoline–powered cars. Those mass-production techniques brought the price of gasoline–powered automobiles down to a level that made owning a car possible for millions of middle-class American consumers. The failure of Baker R & L and its electric vehicle competitors to adopt those mass production principles put the firm at a distinct pricing disadvantage. In general, the Baker R & L products were priced at levels consistent with upper-medium priced and luxury cars of the pre- and immediate post-World War I era.

Baker R & L and its competitors were faced with an interesting marketing dilemma. To survive in the automobile industry as it was structured in the early 20th century, the electric automobile producers would have had to design and build vehicles that would have appealed to male consumers. The gasoline vehicle industry had pre-empted that market with cars that were powerful as well as attractive and appealed to the male mind-set. Baker R & L, in its product design and in its advertising, consistently appealed to female consumers. Initially, that appeal was based on the electric car being easy to start (no hand-cranking) and clean to operate. As the gasoline–powered automobile became more reliable and had electric starters and became easier to handle, some of the appeal of the electric car began to fade for women. Furthermore, by the nature of the design of the electric cars and the wardrobes portrayed by the women riding and driving the Baker R & L products it was clear the electric car was for the upper-class woman.

The advertising appeal to women by Baker R & L put the firm in what could be considered a marketing trap. It was recognized that women were an important component of the customer base for the electric car. Trying to expand that customer base by a broader appeal to the male consumer risked losing the female customer base that existed. Yet failure to design products and use marketing techniques that would appeal to men meant that opportunities for growth in the market were limited.

The nature of the electric vehicle itself presented some challenges for Baker R & L and other electric auto manufacturers. The cars were relatively slow with 25 miles per hour being a fairly good speed for the electrics. However, gasoline powered cars were being built at very low prices that were easily capable of speeds double to triple that of the electrics.

In addition to the issue of speed, there was the problem of range for the electric vehicles. A range of only 25 to 30 miles before needing the batteries recharged limited the potential mobility of the driver of an electric. Baker R & L was in the forefront of firms seeking improved infrastructure and charging facilities for electric cars. Unfortunately for Baker R & L, that movement never really matured into a nationwide network of charging stations that would have been convenient for the average motorist. The Electric Vehicle Association of America and its successor entity, as part of NELA, made attempts to broaden the appeal of the electric car. At best, those attempts were insufficient and probably too late in implementation to overcome the technical and other marketing challenges faced by Baker R & L.

Thus, a number of factors combined to make it difficult for electric vehicle manufacturers to survive in the business environment of the first quarter of the 20th century. From all indications, the Baker and Rauch & Lang companies and the combined Baker R & L firm basically were well managed. Their products were excellent. However, a combination of technological issues and an inability, or perhaps even failure, to design and price vehicles that would appeal to a broad segment of the automotive market meant that the exit of Baker R & L from the passenger car industry was not a surprise.

References

1912 Rauch and Lang TC Brougham. (n.d.). Retrieved July 2, 2012, from conceptcarz.com/vehicle/z10300/Rauch-and-Lang-TC-Brougham.aspx

"Auto Merger Refuted." (1912, July 28). *Cleveland Plain Dealer*, 8A.

Auto Plants Here Work on Merger. (1915, June 5). Cleveland Plain Dealer, 1.

Automobile Section. (1907, February 17). *Cleveland Plain Dealer*, 1-8.

Automobile Section, Part Two. (1907, February 17). *Cleveland Plain Dealer*, 1-8.

Automotive News. (1996, April 24). *One Hundred Year Almanac and 1996 Market Data Book*. Detroit, MI: Crain Publications.

Baker 1898-1915, Baker Motor Vehicle Co.,1915-1916 Baker Rauch & Lang. Retrieved Feb. 7, 2015 from earlyelectric.com/carcompanies.html

Baker and Rauch and Lang corporate news announcements. (1907, May 19). *Cleveland Plain Dealer*, 20.

Baker and Rauch and Lang corporate news announcements. (1907, May 26). *Cleveland Plain Dealer*, 3.

Baker Electric Co. (1907, May 26). *Cleveland Plain Dealer*, 3.

Baker Electrics. (1914). The Baker Motor Vehicle Company Catalog, 1914. In the collection of the Western Reserve Historical Society, Cleveland, Ohio.

"Baker Electric Racing Automobile (The)." (1902, June 14). *Scientific American*, 86 (24), 419.

Baker Electric Vehicles. (1908). The Baker Electric Motor Vehicle Company Catalog. In the collection of the Western Reserve Historical Society, Cleveland, Ohio.

Baker Motor Vehicle Company (The). (n.d.). Baker Electric Catalog. In the collection of the Western Reserve Historical Society, Cleveland, Ohio.

"Baker Motor Vehicle Co. (The)." (1907, May 19). *Cleveland Plain Dealer*, 20.

Baker Motor Vehicle. Wikipedia. Retrieved Feb. 4, 2015, from en.wikipedia. org/wiki/Baker_Motor_Vehicle

Baker Motor Vehicle Company. (1978, May 10, 1978). *The Cleveland Plain Dealer*.

"Baker Bevel Gear Shaft Drive." (1909, November 28). *The New York Times*, S4.

"Baker Commercial Vehicles." (1910, January 16). *The New York Times*, S4.

"Baker, Rauch & Lang; Baker-Raulang." (n.d.). Coachbuilt. Retrieved May 30, 2015 from coachbuilt.com/bui/b/baker_raulang/baker_raulang .htm

Baker, R. & L. Business Growing. (1920, March 30). *Cleveland Plain Dealer*, 19.

Baker R. & L. Co. *Poor's Manual of Industrials, 1916*, 2364.

Baker R. & L. Co. *Poor's Manual of Industrials, 1917*, 1696

Baker R. & L. Co. *Poor's Manual of Industrials, 1918,* 274

Baker R. & L. Co. *Poor's Manual of Industrials, 1921,vol 1*, 160.

Baker R. & L. Co. *Poor's and Moody's Industrials, 1922 vol. 1*, 614.

Baker R. & L. Co. *Poor's and Moody's Industrials, 1923, vol. 1*, 89.

Baker R. & L. Co. *Poor's and Moody's Industrials, 1924 vol. 1*, 123.

Baker R. & L. Co. *Poor's Manual of Industrials, 1925*, 348.

Baker R. & L. Co., The Logical Car of Today With a History of the War 1914-1918: Rauch & Lang Electric. Product catalog.

"Baker-Raulang Co. Declares Dividend." (1952, Feb. 7). *Cleveland Plain Dealer,* 18.

Beckman, A. (2014, December). Off The Records re: Studebaker Electric Automobiles. *Turning Wheels, 46, no. 12*, 18 – 20.

Bigelow, L., Carroll, G., Seidel, M-D. (1997). "Legitimation, Geographical Scale, and Organizational Density: Regional Patterns of Foundings of American Automobile Producers, 1885–1981." *Social Science Research,* 26, 377-398.

Brings in New era for Auto Industry. (1912, October 28). *The Cleveland Plain Dealer,* 1.

Bureau of the Census. (1917). *Abstract of the Census of Manufacturers, 1914*. Washington, DC: U.S. Government Printing Office.

Bureau of the Census. (1923). *Abstract of the Census of Manufacturers, 1919*. Washington, DC: U.S. Government Printing Office.

"Canadian Plants for Baker." (1912, May 26). *The Cleveland Plain Dealer*, 4B.

"Claim Rumor Unfounded." (1912, Sept. 1). *The Cleveland Plain Dealer*, 11A.

"Cleveland Manufacturers of Electric Cars Move to the East." (1920, Jan. 18). *The Cleveland Plain Dealer*, 105.

Coachbuilt. Baker, Rauch & Lang; Baker-Raulang. (n.d.). Coachbuilt. Retrieved May 30, 2015, from coachbuilt.com/bui/b/baker_raulang/baker_raulang.htm.

"Cost of Running Commercial Wagon." (1912, Jan. 14). *The New York Times*, XX1.

Creates Interest in Closed Cars. (1914, January 11). *The Cleveland Plain Dealer*, 47.

Didik, F. (1997). "History of Electric Cars from 1834–1987." Retrieved Dec. 22, 2014, from electrifyingtimes.com/didik.html

Electric Vehicles Magazine issues used:

Vol. 3, No. 5, May 1913

Vol. 3, No. 6, June 1913

Vol. 3, No. 7, July 1913

Vol. 3, No. 8, August 1913

Vol. 3, No. 9, September 1913

Vol. 3, No. 10, October 1913

Vol. 5, No. 1, July 1914

Vol. 5, No. 2, August 1914

Vol. 5, No. 3, September 1914

Vol. 5, No. 5, November 1914

Vol. 5, No. 6, December 1914

Vol. 6, No. 1, January 1915

Vol. 6, No. 2, February 1915

Vol. 6, No. 3, March 1915

Vol. 6, No. 4, April 1915

Vol. 6, No. 5, May 1915

Vol. 6, No. 6, June 1915

Vol. 7, No. 1, July 1915

Vol. 7, No. 4, October 1915

Vol. 7, No. 5, November 1915

Vol. 8, No. 1, January 1916
Vol. 8, No. 2, February 1916
Vol. 8, No. 3, March 1916
Vol. 8, No. 4-5, April – May 1916
Vol. 8, No. 6, June 1916
Vol. 9, No. 2, August 1916
Vol. 9, No. 3, September 1916
Vol. 9, No. 4, October 1916
Vol. 9, No. 5, November 1916
Vol. 10, No. 1, January 1917
Vol. 10, No. 2, February 1917
Vol. 10, No. 3, March 1917
Vol. 10, No. 6, June 1917
Vol. 11, No. 1, July 1917
Vol. 11, No. 2, August 1917
Vol. 11, No. 3, September 1917
Vol. 11, No. 5, November 1917
Vol. 11, No. 6, December 1917

Epstein, R. C. (1928). *The Automobile Industry, Its Economic and Commercial Development.* Chicago: A. W. Shaw Company.

Florey, B. (2015, Sept.-Oct.). "Time for Some Trivia." *The Divco News,* 136, 4-5.

"Gossip of the Automobilists." (1910, December 11). *New York Times*, C8.

Griswold, W.S. (1954, June). "The Car That Has Changed.) *Popular Science,* 138–142, 252.

Handy, G. (2006). Early Electric Car Site.

Car Companies. Retrieved Feb, 7, 2015, from earlyelectric.com/carcompanies.html.

"Has Grown Rapidly." (1910, February 20). *The Cleveland Plain Dealer*, 22.

Hedgbeth, L. (n.d.). "Rauch and Lang Electric Cars: Cars of Social Prestige." Retrieved May 30, 2015, from secondchancegarage.com /classic-car/rauch-and-lang-1.cfm.

"History of Baker (The)." (1966, August 15). Baker R&L Corporate News Release. Cleveland Press Collection of the Cleveland State University.

"History of Electric Powered Motor Cars/Automobiles." (n.d.). Retrieved June 23, 2015, from carhistory4u.com/the-last-100-years/electric-powered.

"History of Electric Vehicles." (n.d.). Retrieved June 23, 2015 from electricvehiclesnews.com/History/historyearly.htm.

"Home for Electric Autos." (10, December, 1914). *New York Times*, 11.

Johnson, D. E. (n.d.). "Detroit Electric-A real electric car company." Retrieved Dec. 23, 2015 from dejohnsonauthor.com/detroit-electric.html.

Kelly, M. (1977, March 4). "Germans Buy Control of Otis' Baker Unit." *The Plain Dealer*.

Kimes, B. R. and Clark, H.A., Jr. (1996.) *Standard Catalog of American Cars 1805–1942, 3rd ed.* Krause Publications.

Kion North America. Retrieved Jan. 10, 2016 from kionna.com/en/kion_na/ kna_company_profile/company_profile_2.jsp

Kirsch, D.A. (2000). *The Electric Vehicle and the Burden of History*. New Brunswick, NJ: Rutgers University Press.

Klepper, S. (30, December, 2001). "The Evolution of the U.S. Automobile Industry and Detroit as its Capital." Retrieved July 14, 2014, from druid.dk/uploads/tx_picturedb /dw2002-440.pdf.

Lamm, M. (2011, February 21). Electric Baker Torpedo Racers. Retrieved June 23, 2015, from deansgarage.com/2011/electric-baker-torpedo-racers/.

Linde Material Handling Equipment. Retrieved Nov. 15, 2014 from lmh-na.com/index.php.

"Logical Car of Today (The), With a History of the War." (1918). Rauch & Lang catalog in the collection of the Western Reserve Historical Society.

Love, J.W. (1919, July 16). "From Old Time Coaches to 1920 Electrics." *Cleveland Plain Dealer,* 76.

"Men Who Put Through $2,000,000 Auto Deal." (1915, June 6). *Cleveland Plain Dealer*, 3B.

Milburn Light Electrics. (2008). milburn. us/history.htm. Retrieved Jan.15, 2015.

Mom, G. (2004). *The Electric Vehicle, Technology and Expectations in the Automobile Age*. Baltimore, MD: Johns Hopkins University Press.

"Motocycle Race." (1895, November 16). *Scientific American,* 73, (20), 315.

Moody's Analyses of Investments, 1922. Baker R&L Co., 405.

Moody's Manual of Railroads and Corporation Securities, 1914. Industrials.

O'Malley, M. (2008, November 4). "Baker Electric Car Site to Become Offices." *The Plain Dealer,* B1.

O'Malley, M. (2008, Nov. 4). "Baker: 1st Electric Car Maker in City." *The Plain Dealer,* B3.

"One of the World's Largest." (1910, Jan. 23). *The Cleveland Plain Dealer*, 22.

"Orders More Electric Trucks." (1912, May 5). *The Cleveland Plain Dealer*, 5B.

Poor's and Moody's Manual, 1921, vol. I, Industrials. Baker R&L Co., 160.

Poor's and Moody's Manual, 1922, vol. I, Industrials. Baker R&L Co., 614.

Poor's and Moody's Manual, 1923, vol. I, Industrials. Baker R&L Co., 89.

Poor's and Moody's Manual, 1924, vol. I, Industrials. Baker R&L Co., 123.

Poor's and Moody's Manual, 1925, vol. I, Industrials. Baker R&L Co., 348.

Poor's Manual of Industrials, 1914. Manufacturing and Miscellaneous Companies.

Poor's Manual of Industrials, 1916. Baker R&L Co., 2364.

Poor's Manual of Industrials, 1917. Baker R&L Co., 1696.

Poor's Manual of Industrials, 1918. Baker R&L Co., 274.

Rauch & Lang. (n.d.). Retrieved Febr. 7, 2015, from earlyelectric.com/carcompanies.html

"Rauch & Lang." (2005). Retrieved May 30, 2015, from classiccar4you.com/classic-cars-gallery/?album=724 &gallery=1196

"Rauch & Lang Carriage Co." (1907, May 12). *The Cleveland Plain Dealer,* 37.

"Raulang." (2005). Retrieved May 30, 2015, from cartype.com/pages/1586/raulang

Ray, R. (2011). "The One-Legged Car Guy." *The Classic Car,* 59(2), 10 – 16.

Robertson, W. (1917, January 31). "Auto Men Lease Building on Superior Av. Downtown." *Cleveland Plain Dealer,* 18.

Santini, D. J. (2011, September 6). "Electric Vehicle Waves of History: Lessons Learned about Market Deployment of Electric Vehicles." Retrieved June 23, 2015, from intechopen.com/download/pdf/18663

"Savant Made Worm Gear." (1914, January 11). *The Cleveland Plain Dealer,* 51.

Schiffer, M.B. (1994). *Taking Charge*, *The Electric Automobile in America*. Washington, DC: Smithsonian Books.

Schmidt, J.K. (1921, July 24). "Automobile Industry's Growth." *Cleveland Plain Dealer,* 7.

Seltzer, L. H. (1928). *A Financial History of the American Automobile Industry*. Boston: Houghton Mifflin Company.

"Show Long Mileage." (1910, November 13). *Cleveland Plain Dealer,* 5.

Sinsabaugh, C. (1940). *Who, Me? Forty Years of Automobile History*. Detroit, MI: Arnold-Powers, Inc.

Sommerlad, R. F. (1964, March 11). "Walter C. Baker." In the collection of the Western Reserve Historical Society.

"Start Legal Patent Fight." (1911, September 10). *The Cleveland Plain Dealer,* 14.

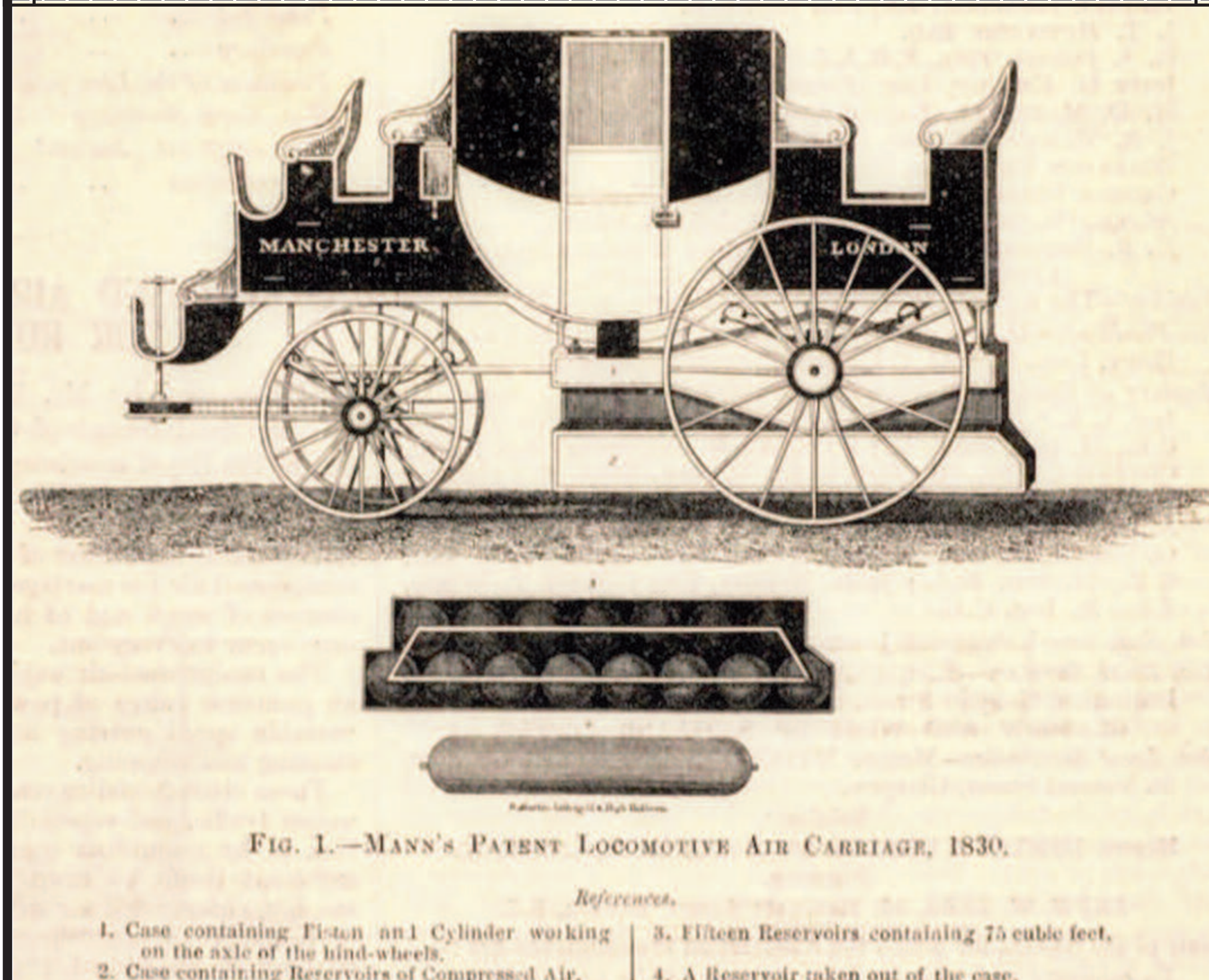
The Story of the Owen Magnetic Car. (n.d.). Owen Magnetic Catalog in the collection of theWestern Reserve Historical Society.

Wager, R. (1975) "Golden" Wheels. Cleveland: Western Reserve Historical Society.

Wakefield, E. H. (1994). *History of the Electric Automobile, Battery-Only Powered Cars*. Warrendale, PA: Society of Automotive Engineers, Inc.

"Will Build Auto Plant in Canada." (1912, June 25). *The Cleveland Plain Dealer*, 9.

A Portuguese Hybrid Car from the Early 20th Century: A Case Study on Innovation Towards Energy Saving



By José Barros Rodrigues, Ph.D.
CIUHCT Member, Portugal

Illustrations and photos from the author's collection unless otherwise noted

Fig. 1: William Mann's vehicle, circa 1822. Source: www.gracesguide.co.uk

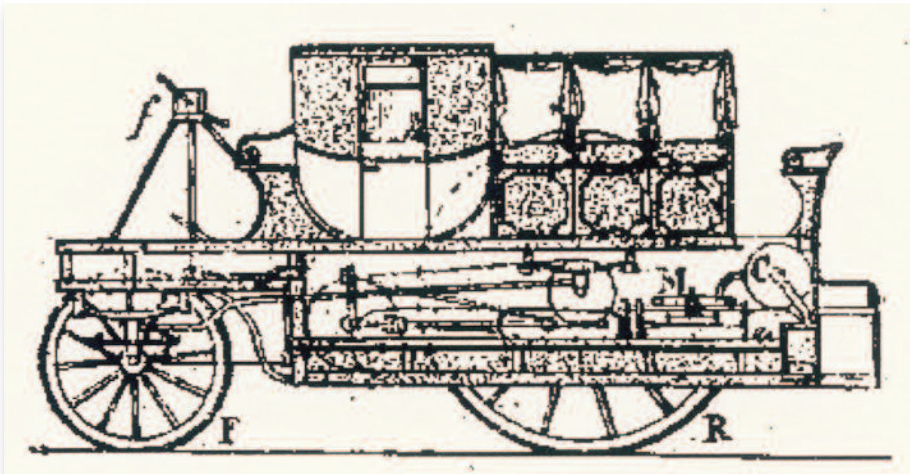


Fig. 2: Wright's car, circa 1830. Source: Le Chauffeur (Paris), October 25, 1897, 371.

During the early years of the 20th century, there were attempts in Portugal to produce prototype motor vehicles of different types and layouts. However, at the end of 1910, Alberto Antunes proposed not merely a new prototype but an innovative solution that he claimed to be cheaper and to give cleaner mobility. Antunes, former chauffeur of the Portuguese Royal Family, presented an ingenious design based on the use of compressed air as its "primary fuel." The key to the design was the adaption of two pressurized shell containers on a common chassis, both charged with compressed air. The released air was intended to drive a crankshaft linked to the rear axle, as in a steam engine, generating movement of the car.

Although an interesting idea it presented huge practical problems, principally the amount of compressed air necessary for dependable regular movement. Two complementary solutions were proposed for compressed air storage: on one hand, a small, three-horsepower petrol engine continuously supplying compressed air to the shell containers; on the other hand, the inertial movements of the car, such as suspension rebounds, were to be used to compress more air.

Despite the technical solutions introduced, the first road test showed a significant lack of range and the project was abandoned. The failure of the test concealed the innovative potential of the idea, since this car would have been a true hybrid vehicle. Lack of time and lack of money in an adverse political context–the republican revolution erupted a couple of weeks later–forced Antunes to give up his project. Nevertheless he was able to pursue the idea of developing an original project for a compressed air powered braking system which was adopted with considerable success to some existing vehicles in Lisbon.

A Short History of Compressed Air

The use of compressed air as motive power for vehicles was one of many ideas that came into the minds of inventors during the 19th century. Fools or visionaries, scientists or creative apprentices, many invested their time and money in the design of vehicles running through compressed air devices. One of the most devoted to the cause was the Frenchman M. Andraud. His belief in this system of motive power was not only technical but philosophical (2) and he once described it as "the undeniable future universal motion." (3) He produced a body of theoretical work and in 1839 published a book summarizing his ideas and the potential applications for compressed air.(4)

Nevertheless, despite the interest-

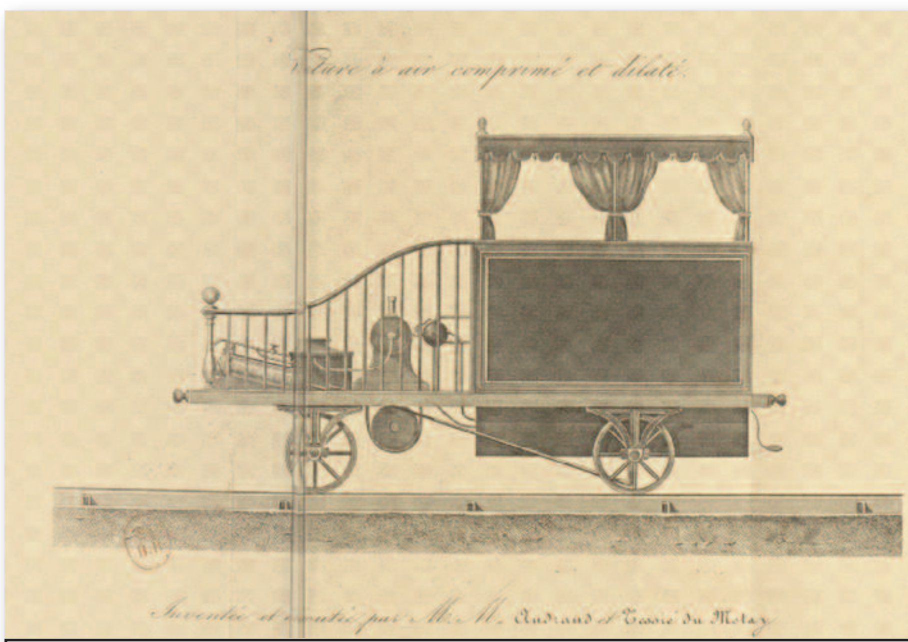


Fig. 3: Scheme of Andraud and Tessié du Motay car, used on a practical test- July, 1840.

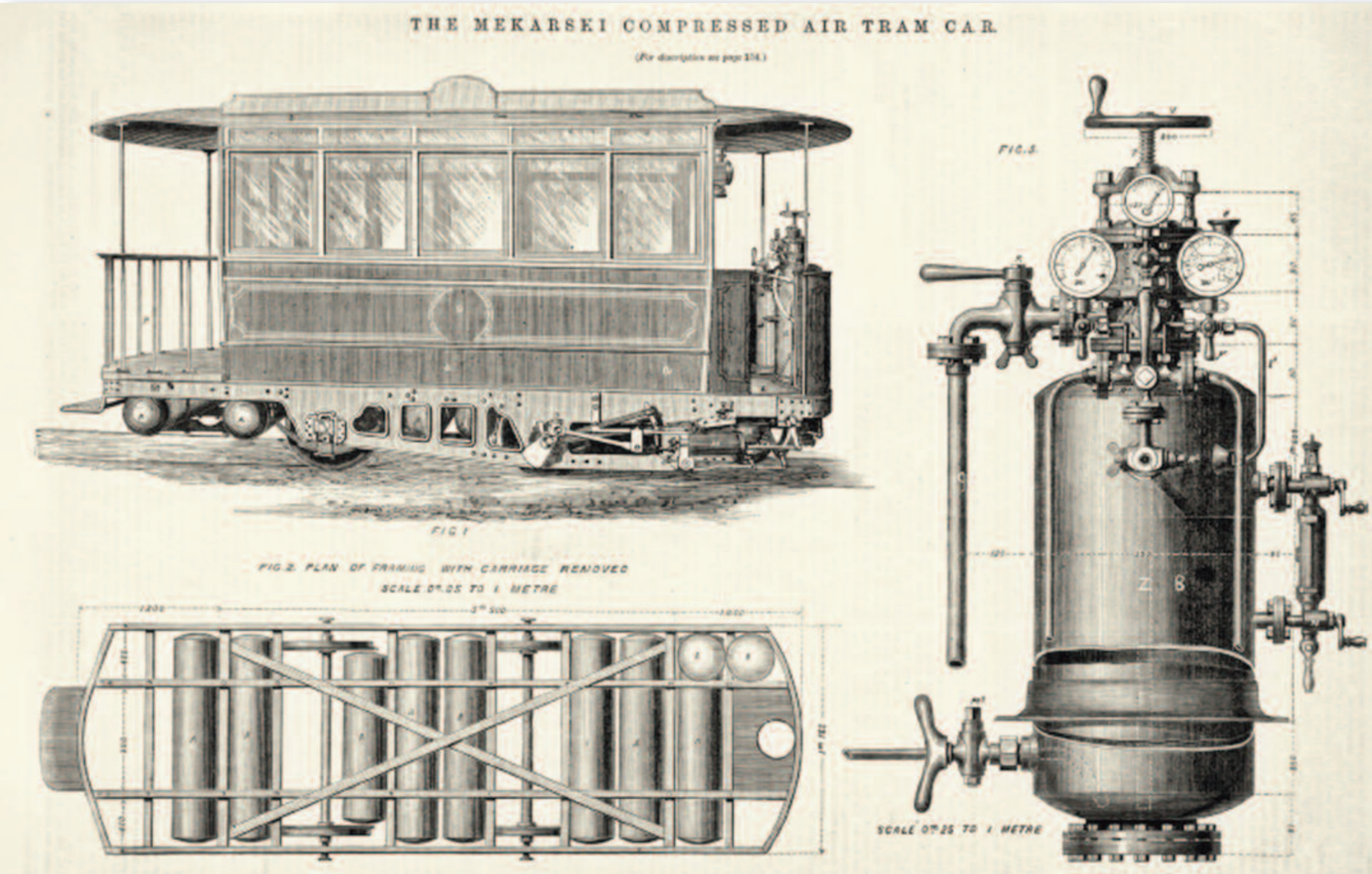


Fig. 4: Layout of Mekarski tramcar in the French city of Nantes. Source: *The Engineer* (London), March 4, 1881, 155.

Fig. 5: The Mekarski tramway car in its two-floor version. Source: *Ilustración artística* (Barcelona), June 6, 1903, pp. 14.

ing advances and practical results obtained by Andraud and his friend Tessié du Motay, the history of air elasticity adapted to vehicular motion originated earlier with Denis Papin in 1687 (5) with his presentation of a paper to the Royal Society "Machine propre à transporter au loin la force des rivières. (6) But it would be 120 years before the first thoughts on the issue became a reality. In the beginning of the 19th century, several proposals considering the elasticity of air as motive power came to public attention. The first to publish conceptual ideas was the British mechanic, George Medhurst. (7) Despite the lack of real data and operational figures resulting from trials, (8) some took Medhurst seriously and developed his ideas in a more practical context. (9)

Medhurst never tested the efficiency of his pneumatic dispatch, but a few years before his death, another English engineer made a trial of a system based on the same principle. It was in 1824 when John Vallance demonstrated a model in Brighton. He was running a small passenger carriage inside a wooden tube. He was the first patentee of an air propelled transportation system and even obtained a grant to use it on a proposed link between his town and London.

Later, William Mann of Brixton studied the application of compressed air to road vehicles. He patented his device and in 1822 published a long report revealing details of the vehicle including descriptions and several drawings. The compressed air tanks, 15 in total, were placed below the frame and had a total capacity of 2.5 cubic meters. Despite the lack of relevant information–namely a correlation between the tank pressure and the final range–there is no evidences of any road test of Mann's vehicle. (10)

In 1830, Wright presented advanced research with more accurate studies. He was one of the first to propose the heating of the air before its admission to the cylinder as a way to improve efficiency. Fordham in 1832 and Rathes (Putney) in 1848 also announced their contributions to the method but without evidence of significant and public road tests. (11)

According to a French journal, the first vehicle with this particular engine, running on a railway, was the prototype built according to general design of Andraud and Tessié du Motay in Chaillot on July 19, 1840. (12). The vehicle had only three wheels but could carry eight people. It was described in extensive detail in a book written by the designers gathering relevant data from the Chaillot test. An illustration of the car used on the railroad was published in that work. (13)

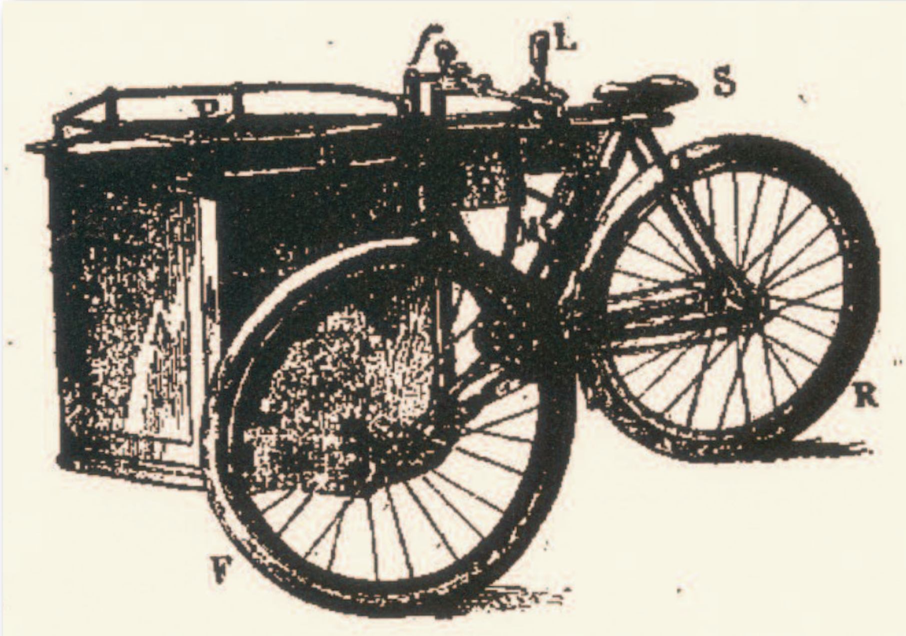


Fig. 6: The Hartley tricycle. Source: *Le Chauffeur* (Paris), October 25, 1897, 374.

Samuel Clegg and Jacob Samuda, working from the patent of Henry Pinkus–an American inventor living in United Kingdom–designed and eventually successfully operated an atmospheric railway using vacuum instead of overpressure several years after Andraud and du Motay's public trial.

Air powered lines began operating in number of cities and were tested in many others. In practice, they were cleaner than steam power but more expensive and not as convenient in operation as electric power. In 1844, a line was opened in Ireland between Kingstown and Dalkey. Two additional English lines were operated each for one year and finally in 1846 France also saw its atmospheric railway running for fourteen years until 1860. (14)

On the roster of names of those who pioneered compressed air engines one should also include William Buckle Reynolds, who in 1844 submitted a method "to power locomotives with compressed air obtained from a device in which atmospheric air was pressurized by internal combustion." (15)

Another Englishman, Robert Roger, also developed his own method for a patent application in the United Kingdom:

> "I first cause the force produced by the explosion of any gas, gases or body to act against a piston or pistons, which are forced out against and compress atmospheric air into a suitable receiver, from whence it is used in lieu of steam to act against a piston, and thereby communicate motion to machinery." (16)

VÉHICULES A AIR COMPRIMÉ

PARIS

Molas, Lamielle & Tessier, 45, r. du Chemin-Vert. — Automobiles pour poids lourds. Omnibus fiacres, voitures de livraison, camions, etc. Moteur à air comprimé, force variable de 1 à 35 chevaux. Adaptation de ce système à tous systèmes de voitures.

BELGIQUE

Belgica (Société anonyme des Cycles et automobiles), 11, rue Van der Straeten à Bruxelles. — Voitures à moteur mixte, à pétrole et à air comprimé.

ÉTATS-UNIS

Buckley (T.-H.) & Co, Worcester (Mass.).
Buffalo - Rochester Electric Power & Automobile Co, Rochester (N.-Y.).
Continental Compressed air Power Co, Camden (N.-J.).
International air Power Co (N-Y.)
Liquid air Power & Automobile Co. 186 Devonshire street, Boston.
New-York autotruck Co, 253, Broadway, New-York.
North american air Motor Co. (N.-Y)
Rochester Electric Motor Co, Rochester.

Fig. 7: List of "Compressed Air" automobile makers. Source: *Annuaire Général de L'Automobile* (Paris: F. Thévin & Ch. Houry, 1901), 116.

Horst Hardenberg has done extensive historic research on pneumatic locomotion presenting examples of several devices designed during the 19th century, some with an undeniable lack of common sense but others gathering interesting ideas suitable for further development:

> Considering the many different machine tools powered by compressed air that came into use many decades later, Reynolds's proposal (…) was not at all unrealistic. The same applies to a similar idea [of] Robert Roger. (17)

We have demonstrated in outline that practical experience using compressed air as motive power was studied and tested in Europe and in the United States during the first half of the 19th century. However, it was not until the 1870s that the commercial exploitation of compressed air systems for machinery and vehicles began. At the time compressed air was always stressed as steam's competitor, mainly for extreme service conditions as well as in locations with severe constraints, such as mining or subways, as was noted by Lotysz:

> Although the idea of pneumatic railway is as old as the steam locomotion, it was mainly contemplated where steam traction could not be adopted. In 1840s the atmospheric railroads were suggested mainly on hilly sections, too sharp for contemporary locomotives. Later, in 1860s, it was proposed for underground city railway systems as it posed less ventilation problems than steam operated trains. In 1880s air powered tramways were operated in number of cities and tested in many others. They were cleaner than steam ones but not so convenient in operation as electric ones. (18)

But the idea of using compressed air engines for regular business, especially in public transport, was always in the minds of businessmen, entrepreneurs, engineers and other enthusiasts. The most interesting examples come from Europe and particularly from France, where an engineer took the technology as far as it was conceivable with the materials and construction methods available at the time.

The Commercial Experiences

Louis Mekarski was perhaps the most famous name associated with compressed air engines for transport of passengers and goods during the last quarter of the 19th century. For several years tramways developed by Mekarski using compressed air as a power source were running from the French city of Nantes to Doulon, a run of 2.8 miles distance.

Born in Clermont-Ferrand, of Polish origin, Mekarski tested his device in Paris in 1876 and then went to Nantes, three years later, where his trams acquired popularity, growing to a fleet of 94 cars by 1900. The Mekarski tramcars continued in use there until 1917, when they were replaced by electric trams. (19)

Mekarski system tram networks were also built in other towns in France: Vichy (1895), Aix-les-Bains (1896), La Rochelle (1899), and Saint-Quentin (1901). (20)

The system was also used in England on the Wantage tramway, but investors shut down the line when they discovered that the compressor plant used more than four times as much coal as a steam locomotive. Between 1881 and 1883 an improved air car was used on the Caledonian Road tramway of the London Street Tramway Company. (21) The magazine, *The Engineer,* made some regular visits to the Nantes-Doulon line and gave interesting conclusions regarding the feasibility and regular scheduling of lines:

> As the summary of the foregoing, I beg leave to say that the Mekarski compressed air system is one that is thoroughly manageable, and in every way trustworthy to do tramway work from day to day under any or all of the conditions imposed by tramway work in large and crowded towns–Nantes has a population closely approaching 120,000–and I say this, speaking of it as it now exists at Nantes, but that improvements can and will be made I feel perfectly certain, improvements not in the system but in the details of its working. (22)

Fig. 8: Molas, Lamielle & Tessier Company advertisement. Source: ***Annuaire Général de L'Automobile*** **(Paris: F. Thévin & Ch. Houry, 1901), 117.**

For some lines, Mekarski developed two-story cars to transport more passengers and increase financial return to the companies.

In the United States, there are also records of the adoption of this special motive power, particularly in coal mines where compressed air was necessary to avoid sparks, flames, high temperatures or steam leaks released by other types of engines.

The Mekarski compressed air engine was a one-stage device with an air heating system able to saturate the air with steam to raise output power. Further evolutions were focused on an increase in engine efficiency. Robert Hardie (1892) retained the main concept of the Mekarski engine (work produced with the expansion of the piston) but improved the reheating process. The Hoadley-Knight system (1896) was the first air powered transit locomotive to use a two-stage engine. And Charles Hodges brought a new standard of efficiency in comparison with previous generations of "air engines" through the use of a two-stage cycle associated with an interheater between the two piston stages to warm the partially expanded compressed air with the surrounding atmosphere. (23)

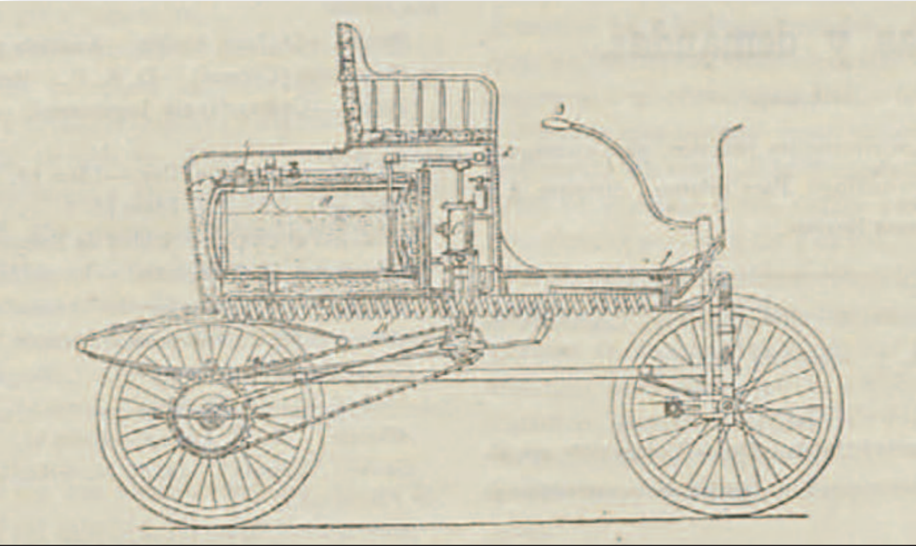


Fig. 9: Layout of the vehicle presented by Liquid Air Power & Automobile at the Agricultural Hall in London. Source: *La Energía eléctrica* (Madrid), July 10, 1902, 24.

The First Automobiles

In 1894, the newspaper *Petit Journal*, under the direction of Pierre Giffard, announced the organization of an exclusive race for automobiles between Paris and Rouen. The enthusiastic reception of this initiative can be appreciated through the list of entries received from 102 dedicated drivers. The types of cars and particularly their engines were also interesting topics reflecting the positive atmosphere of the event.

In addition to "conventional" proposals (petrol, steam, and electricity) there were also strange motive powers for some of the other participants, among them: hydraulic engines, compressed water engines, automatic engines, rockers engine, combined liquid engines, combined steam engines, electro-pneumatic engines, and so on. (24) For the record, four of the entries were powered by compressed air.

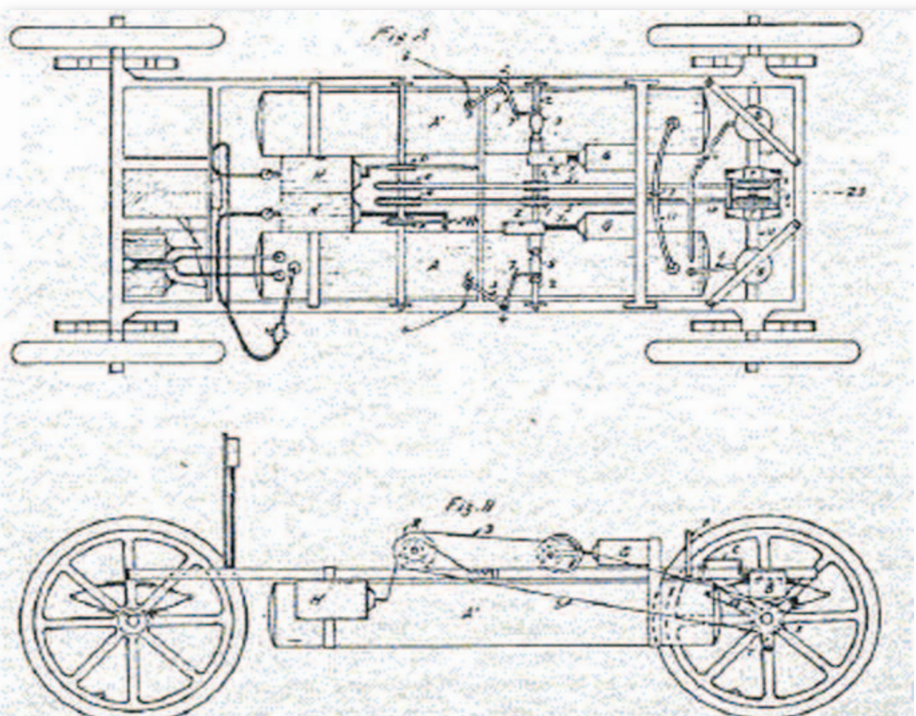


Fig. 10: Layout of the vehicle according to patent specifications. Source: Portuguese Patent Nº 7047, November 24, 1909.

In order to ensure a real event with feasible cars and to exclude charlatans, the regulators required an early trial race of 50 km with a maximum duration of three hours to eliminate the so-called "baroque engines" as well as the trick proposals. Eventually only 21 automobiles were accepted to enter the race: 14 with petrol engines and 7 powered by steam. In the end, beside the preposterous engine using "compressed water" or similar, the failure of compressed air engines, together with the electrics, in the event was far from unexpected.

The story confirms the ultimate problem related to this type of engine, that is, its range. Nevertheless, engineers and other "mechanical sorcerers" insisted on the advantages the compressed air system, its clean and smooth delivery of power–while others pursued their experiences with electric motive power.

Probably the first vehicle built for road use was the small tricycle designed and built by Hartley Power Supply Company of Chicago. (25) This tricycle was intended for postal service and apparently was used on postal fleets in Chicago and Washington. But at the end of the 19th century, there was no regular production of compressed air engines for cars, either in the United States or in Europe.

The tramway cars on lines of short length were the only vehicles operating with this power system while steam and electricity were leading the way with better arguments relating to the cost of operation. By the beginning of the 20th century, the production of compressed air automobiles was unusual and its volume residual. In 1901, a French publication dedicated to the automobile gave a brief summary of the compressed air automotive industry around the world, publishing a short list of the known producers. (26) The list includes only one manufacturer in France, another one in Belgium and eight names in the United States.

The French builder Molas, Lamielle & Tessiers, with its premises in Paris, was an assembler rather than a producer whose core business was to "adapt any kind of engine to the compressed air system especially for heavy duty vehicles."

The same magazine carries an advertisement for the company but figures and details of production are not revealed. Molas, Lamielle & Tessier had previously patented a compressed air engine with the following general description:

> The engine is designed for working motor cars, and has four single-acting cylinders in pairs. The cranks of one pair are at 180 (degrees) to each other and at 90 (degrees) to those of the other pair. (27)

They also presented a power driven vehicle patent (28) which stresses that their knowledge of the automotive industry was relevant, although their production probably was not as regular as expected due to a lack of

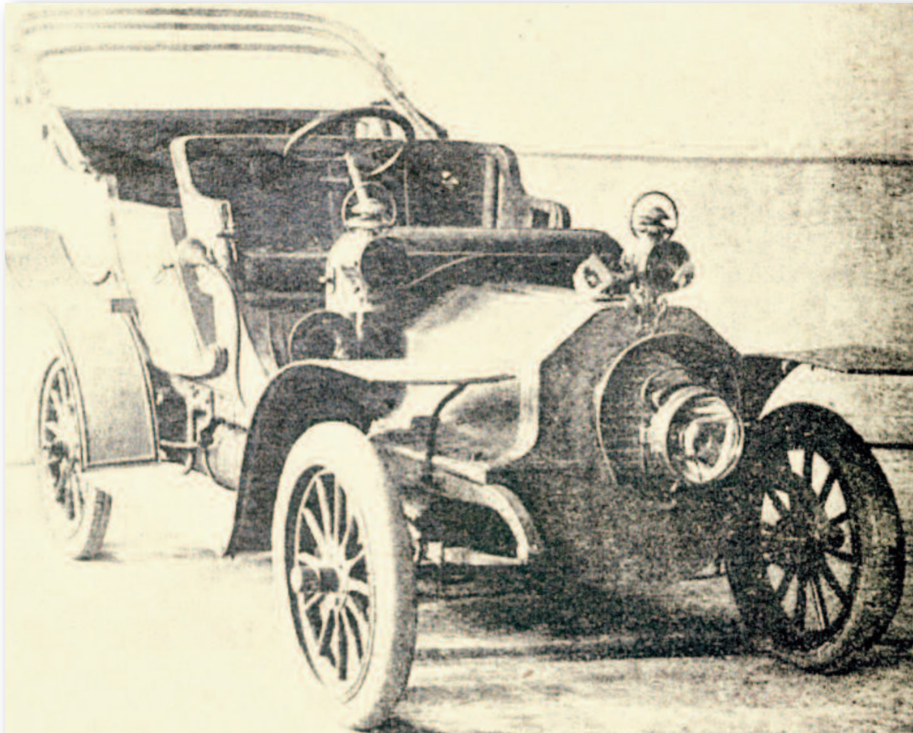


Fig. 11: The prototype during its official presentation. Source: *Sports Ilustrados* (Lisbon), September 24, 1910, 6.

demand. Their presence at motor shows and exhibitions may have been a stimulus to attract additional production orders. In fact, their work drew the attention of American automotive press:

> The delivery-wagon represented herewith, constructed by Messrs. Molas, Lamielle and Tessier, was exhibited at the second Exposition des Tuilleries, where it attracted considerable attention by reason of the relative simplicity of arrangement of its maneuvering devices and the limited amount of space occupied by the motive apparatus. In this vehicle, the air-storage reservoirs employed consist of hammered steel tubes of 8-inch external diameter. The heating is done directly by gasoline, instead of by steam from a boiler, as in the Mekarski system; the manufacturers being of the opinion that, since a direct heating of the air permits it to be raised to a temperature much higher than that which could be obtained by means of heating by steam, they obtain also a greater increase of volume and, consequently, of work that compensates for the heating during expansion obtained with the above-named system. (29)

Unfortunately, there are no figures about their production and sales volume regarding compressed air engines for vehicles.

The Belgian concern is also little known. Belgica was a small producer whose first car was an electric.

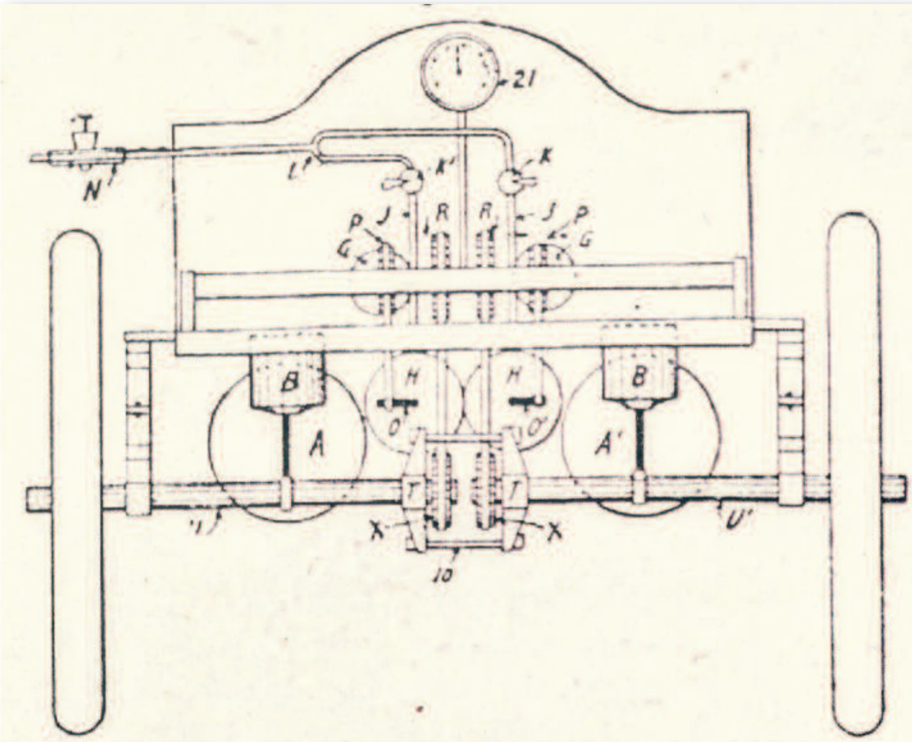


Fig. 12: Rear view of vehicle's layout. Source: ***Sports Ilustrados*** **(Lisbon), September 24, 1910, 6.**

There are no production records of any kind calling for a compressed air engine. The reference in the list may be an advertising claim rather than an industrial commitment. (30)

On the other hand, in the United States, the list of vehicle builders is vast: Buckley, Buffalo–Rochester Electric Power & Automobile Co., Continental Compressed Air Power, International Air Power, Liquid Air Power & Automobile, New York Auto Truck, North American Air Motor and Rochester Electric Motor.

There are references in the European press, especially in technical magazines, to the proposal of Liquid Air Power & Automobile following the display of a prototype in 1902 at the Agricultural Hall in London. An article was published in Madrid in a specialized magazine, *La Energia Electrica*, with technical information concerning consumption, working pressures and average range. (31)

The Portuguese Experience

In September 1910, the Portuguese press was surprised by a novelty: a former chauffeur, Alberto Antunes, announced a vehicle prototype "fueled" by compressed air. We do not know what kind of spark triggered Antunes's imagination to design such a car but we know, for sure, that some months before he had begun the study of compressed air devices adapted to power braking systems. Why? In 1909, he had suffered a leg injury which meant losing enough strength to use it for the operation of mechanical cable brakes. In response, he conceived the idea of using compressed air to power the braking system of his own car. (32)

The novelty of the system was the fact that air was compressed through the use of special pumps fitted on both axles of the car. The pumps were powered through the suspension's rebounds and, according to Antunes, it was sufficient to ensure working pressure for these primitive servo brakes.

Without any technical training, Antunes assumed that it was possible to extrapolate the same principle to move a car. He claimed a patent for his device on the 24th of November, 1909, a few months after his power brake patent. This new patent was granted on the 8th of March, 1910, and it is reasonable to assume that Antunes was able to test his prototype before that date, measuring range, consumption and overall efficiency of the system.

The text of the patent was vague. Antunes presented the general principle but did not provide technical or numerical information. Further, there are no feasible explanations about one of the crucial components of the car, its engine. In addition, nothing is revealed about the pump's efficiency, a fundamental criterion since the success of the system was based on the ability to store a quantity of compressed air sufficient to propel the vehicle. The text of the patent also does not give the working pressure of the container.

The drawings in the patent file show a typical automobile chassis with two huge containers, longitudinally disposed, to store compressed air. On the rear axle beside the differential one can see both pumps that feed the containers. Road tests performed before the settlement for the patent confirmed that the system had limited range. Therefore, for the patent file, a small internal combustion engine, with a total power of

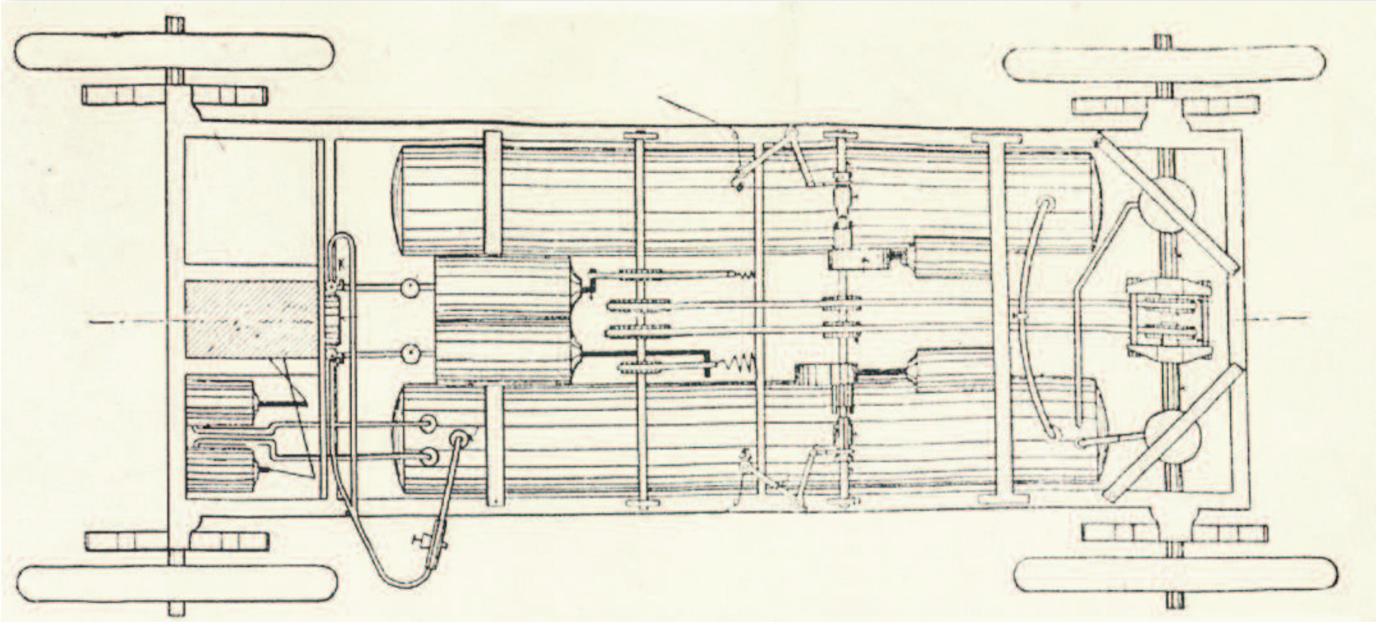


Fig. 13: Plan view of Antunes's vehicle layout showing the air containers. Source: *Sports Ilustrados* (Lisbon), September 24, 1910, 6.

three horsepower, is mentioned to pump additional air to the containers. Unfortunately, information about this small petrol engine is also missing.

At the presentation to the press, Antunes emphasized the use of the internal combustion engine as a crucial improvement to his special vehicle. But no road tests were performed before journalists and no technical information was revealed, which is quite astonishing. A demonstration was scheduled later but on the 5th of October, Portugal was submerged in a political revolution that changed the country. There was no room for inventions.

Conclusions

In the end, there would be no record of public trial and no determination of the vehicle's potential. The containers with an estimated volume of 300 dm3 at an estimated pressure of 30 atm were not adequate to give a reasonable range to the car. In fact, the critical issue lies, still today, on the low energy potential of a compressed air container in comparison to an electric battery.

This question was specifically raised by a French magazine, already in the 19th century:

> The use of compressed air, however, does not seem to us advisable even after the description of this device, given to us in some detail just to arrive at this conclusion: that if one is willing to accept this disadvantage of a vehicle needing at regular intervals to come back to the station to refuel, the electric battery is preferable to the compressed air accumulator, despite the successful experiences of Mr. Hartley's device, praised by American newspapers and *Autocar* magazine, from whom we borrowed this description. (33)

A recent experience with this concept, conducted by PSA Group in France, gives more details to understanding the fundamental technical difficulties of the Portuguese experiment (34). The Peugeot vehicle, with a 250 atm pressurized container could not reach more than 150 kJ, i.e., 20 times less than a Prius battery. (35) With a small container of around 20 liters, the compressed air mode runs for only 10 seconds. However, PSA claimed that its device was feasible through the adoption of a hydraulic engine working in both senses–pumping air for containers when the petrol engine is working or delivering power to the front wheels when the petrol engine is shut down–and a complex electronic management system. Nevertheless, despite his apparent failure, Alberto Antunes gave the public some interesting ideas:

1) The use of suspension rebound movement to fill containers with

compressed air through the action of pumps. The stored compressed air was then recycled to power both braking and clutch operations.

2) If a hybrid vehicle is a vehicle that uses two or more distinct sources of motive power, we must agree that Antunes' car meets the definition since it employs a compressed air engine together with a petrol engine, the second exclusively as a range extender, which was also a novelty in 1910.

Bibliography

Andraud, M., *L'Air Comprimé employé comme moteur ou de la force obtenue gratuitement et mise en réserve*.Paris: Chez Guillaumin Éditeurs, 1839.

M. Andraud and Tessié du Motay. "*De L'Air Comprimé et Dilaté comme force motrice ou des Forces Naturelles Recueillies gratuitement et mises en réserve."* Paris: Chez Guillaumin Éditeurs, 1841.

Annuaire Général de L'Automobile. Paris: F. Thévin & Ch. Houry, 1901.

The Automobile Magazine (New York), 1899.

Boletim de Propriedade Industrial, Lisbon, 1910.

Le Chauffeur (Paris), 1897.

Diário de Notícias (Lisbon), 1910.

La Energía eléctrica (Madrid), 1902.

The Engineer (London), 1881.

GBD189725868 Patent Application, 6th of November, 1897.

Grégoire, Jean Albert. "50 Ans d'Automobile,*" La Voiture Électrique*. Paris: Flammarion, 1981.

Hardenberg, Horst O. *The Middle Ages of the Internal Combustion Engines* (1794-1866) (Warrendale: SAE, 1999, 204.

Harper's Weekly, 1896.

Le Rappel (Paris), 1885.

Le Rappel (Paris), January, 20, 1885, 3.

Lotysz, Slawomir. "Alfred Beach not alone: The American Patents of Pneumatic Railway in 19th Century," *ICON*, Vol. 9, 2003.

Medhurst, George. Calculations and remarks, tending to prove the practicability of a plan for the rapid conveyance of goods and passengers…by the power and velocity of air, London, 1812.

Bob Neal. Compression unit compresses air for free (1936) U.S. Patent No. 2,030,759, 1936.

Robert Roger, Improvements In Obtaining Motive Power, British Patent A.D. 362, 1853.

Sports Ilustrados (Lisbon), 1910.

The Times (London)

Usine Nouvelle, March, 2013.

US Patent 650.516 A, published May 29, 1900.

www.aircarfactories.com.

www.gracesguide.co.uk.

"Hybrid Air, an innovative full hybrid gasoline system", www.psa-peugeot-citroen.com.

Les Constructeurs Belges, www.rvccb.bl.

www.tramwayinfo.com.

References

1. PhD, CIUHCT Member, Portugal

2. "Nous remarquons que la force de l'homme est plus faible et plus coûteuse que celle des animaux ; que la force des animaux est plus faible et plus coûteuse que celle des chutes d'eau et que la force des chutes d'eau est plus coûteuse que celle de la vapeur, le terme naturel de cette progression est d'arriver à une force d'une puissance indéfinie et qui ne coûte rien. Cette force «destinée à changer la face du monde matériel, et par suite, celle du monde moral», c'était l'expansion de l'air comprimé." *Le Rappel* (Paris), January, 20, 1885, 3.

3. "La limite de la compressibilité de l'air est inconnue. «C'est un ressort qu'on bande autant qu'on veut et qui ne casse jamais». Andraud le voyait, se substituant à la vapeur, remplir l'emploi du moteur universel." *Le Rappel* (Paris), January, 20, 1885, 3.

4. Andraud, "L'Air Comprimé employé comme moteur ou de la force obtenue gratuitement et mise en réserve," (Paris: Chez Guillaumin Éditeurs, 1839)

5. "Denis Papin fut le Premier qui songe à trouver dans l'élasticité de l'air une force motrice utilisable ; il procéda non pas par compression mais par raréfaction de l'air atmosphérique: au point de vue des lois physiques qui sont en jeu de principe est le même." *Le Chauffeur* (Paris), October, 25, 1897, 123.

6. This machine was also presented on the work, "Acta eruditorium, Leptiae," published on December 1688, p. 684, under the title, "De usu tuborum pregrandium ad propagandum in bonginquum motricem fluviorum."

7. "An English mechanic George Medhurst is believed to be an originator of the idea. He suggested a pneumatic tube for dispatching parcels or letters as early as in 1810. Two years later he extended his proposal on a much more fragile load–-the passengers." Slawomir Lotysz, "Alfred Beach not alone: The American Patents of Pneumatic Railway in 19th Century," 93-107, *ICON*, Vol. 9 (2003)

8. George Medhurst, "Calculations and remarks, tending to prove the practicability of a plan for the rapid conveyance of goods and passengers… by the power and velocity of air," London, 1812.

9. Slawomir Lotysz, Alfred Beach not alone: "The American Patents of Pneumatic Railway in 19th Century," 93-107, *ICON*, Vol. 9 (2003).

10. *Le Chauffeur* (Paris), October, 25, 1897, 371.

11. *Le Chauffeur* (Paris), October, 25, 1897, 372.

12. *Le Chauffeur* (Paris), October, 25, 1897, 371.

13. Andraud and Tessié du Motay, "De L'Air Comprimé et Dilaté comme force motrice ou des Forces Naturelles Recueillies gratuitement et mises en réserve" (Paris: Chez Guillaumin Éditeurs, 1841).

14. Slawomir Lotysz, Alfred Beach not

alone: "The American Patents of Pneumatic Railway in 19th Century," 93-107, ICON, Vol. 9 (2003).

15. John William Reynolds Buckle, "Improvements on Obtaining Motive Power for Working Locomotive Carriages and other Machinery," British Patent A.D. 1844, Nº 10.404.

16. Robert Roger, "Improvements In Obtaining Motive Power," British Patent A.D. 1853 Nº 362.

17. Horst O. Hardenberg, *The Middle Ages of the Internal Combustion Engines (1794-1866)* (Warrendale: SAE, 1999, 204.

18. Slawomir Lotysz, "Alfred Beach not alone: The American Patents of Pneumatic Railway in 19th Century," 93-107, *ICON*, Vol. 9 (2003).

19. www.tramwayinfo.com.

20. www.aircarfactories.com.

21. "The Improved Mekarski Compressed Air Engine Co", *The Times* (London), June 20, 1883.

22. *The Engineer* (London), March, 4, 1881, 156.

23. www.aircaraccess.com

24. Jean-Albert Grégoire, "50 Ans d'Automobile," *La Voiture Électrique* (Paris: Flammarion, 1981), 57-58.

25. "M. Hartley a pensé que le Moteur à Air comprimé à deux cylindres, qu'il a combiné, et appliqué en particulier à son tricycle, peut répondre aux desiderata très souvent exprimés, quant à l'utilité d'une petite machine légère, simple, compacte, sans vibrations et à changement de sens, propre à actionner des Véhicules et les embarcations de petite taille. L'application faite au cas particulier semble assez réussie quoique ce Véhicule ait, à première vue, l'inconvénient inhérent, du reste, au système dont il est l'application, de devoir la majeure partir de son poids et de son volume à la présence du réservoir à Air comprimé, A, porté par les deux roues d'avant F, directrices au moyen du Guidon double à deux poignées f. Tel qu'il est cependant il a, parait-il, attiré l'attention de M. Hesing, le directeur des postes de Washington et, il a été adopté par l'administration des postes à Chicago, afin de remplacer une partie de sa cavalerie, pour porter des lettres." *Le Chauffeur* (Paris), October, 25, 1897, 373-374.

26. *Annuaire Général de L'Automobile* (Paris: F. Thévin & Ch. Houry, 1901), 116.

27. GBD189725868 Patent Application, November 6, 1897.

28. US Patent 650.516 A, published May 29, 1900.

29. *The Automobile* Magazine (New York), Volume I, October, 1899, 509

30. Daniel Absil, Les Constructeurs Belges, www.rvccb.bl.

31. "En un ligero estudio comparativo entre los diversos agentes motores empleados en el automovilismo, que publicamos recientemente en esta misma sección, indicábamos que si bien el aire comprimido y el aire líquido podían aplicarse como motores de los carruajes auto móviles, la práctica no había aún sancionado su empleo, porque, entre otros inconvenientes, tenían el importante de exigir depósitos de gruesas paredes para el transporte del aire. Por esto – decíamos – llamó bastante la atención en la última Exposición de automóviles de Nueva York un carruaje presentado por la Compañía de aire líquido Implex, que aseguraba tener aquél un radio de acción de 80 kilómetros, no disponiendo más que de un depósito de 45 litros de capacidad. En la Exposición inglesa de l'Agricultural Hall se ha visto un nuevo carruaje con motor de aire líquido, construido por la «Liquid air Power and Automobile Company», cuya Sociedad ha manifestado, no obstante, su decisión de no entregar al público hasta la próxima estación vehículos de este tipo, que está representado en el adjunto grabado. El depósito A está formado por dos cilindros concéntricos, separados por una substancia mala conductora para evitar pérdidas de calor. Su capacidad es de 60 litros, suficiente, según la Compañía, para un recorrido de 35 millas (58 kilómetros, próximamente), a razón de 10 millas solamente por hora. En el radiador B se vaporiza el aire líquido bajo la influencia del calor, que le transmite por contacto la atmósfera; dejando una pequeña cantidad de aire vaporizarse en dicha cámara, se llega en un minuto a obtener una presión de 14 kilogramos por centímetro cuadrado, equivalente a la de los motores de vapor de alta presión tipo corriente. El depósito, y lo mismo el radiador, están provistos de válvulas de seguridad que automáticamente funcionan cuando las presiones llegan respectivamente á los límites de 14,76 y 15,70 kilogramos. La carga del depósito se efectúa por el agujero i , situado en la parte de atrás del carruaje; la válvula de admisión 2 es maniobrada desde el asiento por el conductor por intermedio de una palanca; en 3 se encuentra el mecanismo para dar la dirección y en 4 el peso." *La Energía eléctrica* (Madrid) July, 10, 1902, 24.

32. This was patented in Portugal on March 3, 1909 (Patent Nº 7015).

33. "L'emploi de l'Air comprimé, néanmoins, ne nous parait pas recommandable même après la description de cet appareil, que nous n'avons donné avec quelque détail que pour arriver à cette conclusion : que si l'on est disposé à accepter cet inconvénient du Véhicule actionné par un accumulateur qu'il faut, à intervalles réguliers, ramener à la station pour le ravitailler, l'Accumulateur Électrique est bien préférable à l'Accumulateur à Air comprimé, même à celui de M. Hartley, que les journaux américains et l'Autocar, à qui nous avons emprunté cette description, nous présentent comme un modèle du genre." *Le Chauffeur* (Paris), October, 25, 1897, 373-374.

34. "Hybrid Air, an innovative full hybrid gasoline system," www.psa-peugeot-citroen.com.

35. *Usine Nouvelle*, March, 14th, 2013, Nº 3322.

continued from inside front cover

Louis is absolutely right in highlighting the inadequacies of a small-bore engine as regards valve size and therefore breathing and ultimately efficiency, but in the 1930s, these matters were not terribly important to the average motorist (at least not in Britain). The outstanding example of a small-bore, long-stroke, high-efficiency British engine of this period is the six-cylinder OHV pushrod Talbot engine designed by Georges Roesch.

***

Arthur Jones and Peter Englehard queried in the Letters section of *AHR #56* why GM failed to offer competition to the Volkswagen in the post-WWII years until 1962. The following points cumulatively rather than individually influenced GM thinking at the time.

Because GM had received a considerable tax write-off regarding its Opel investment in Germany during the WWII years, GM was most hesitant to take back control of Opel. As it was GM delayed this decision until late 1948 and even then there were many contingencies and conditions. History showed a devastated economy in Germany just after WWI, so optimism was in short supply three decades later. Yes, the German and Japanese economies showed remarkable growth after WWII but it took a while before this success became evident. Furthermore GM's Alfred Sloan had precious little respect for government economic initiatives of any form, of which the Marshall Plan was one. In Sloan's eyes, governments were clueless when it came to making appropriate decisions regarding the business world.

Raw materials in post WWII Europe were in short supply. Therefore why build lower margin small cars when their raw material requirements were little different from the medium sized cars? While the Russians hijacked the prewar Kadett's manufacturing facilities it should also be noted that the smallest Vauxhall 10 ended production in September 1947 once the fiscal taxes were relaxed in the UK. Additionally, raw material allocations in the UK were based on exports sales and the overseas sellers' market created a demand best supplied by higher margin larger vehicles. As for Opel, the lack of material likely explained why it took until 1950 before export markets such as South Africa started receiving Opels again.

Mercedes-Benz showed a similar outlook to GM's. Their first post-war new design was the high margin 1951 300 series built in short supply because of its high price but also limited raw material availability. The redesign that replaced their ancient bread and butter cars had to wait until the arrival of the 1953 Ponton models.

In a similar vein you need to realize that smaller cars are not necessarily cheaper to build. The labour cost to assemble an engine, transmission or body hardly varies and can be higher in a small car if cramped quarters restrict working room. The same can be true in the use of specific raw materials. I have seen where a larger capacity engine is cheaper to build than the smaller version because the larger pistons were used in greater volume and as such bought at a cheaper price than those fitted to the smaller engine. Yet marketing considerations dictate that the smaller car or engine be sold at a significantly cheaper price.

When GM purchased Opel in 1929, the various layers of personnel and expertise in the company were familiar with building small cars profitably. By late 1948 the depth of German management was much less influential. GM wielded far more influence and Americans simply did not have an appreciation or affinity for small cars. It should be remembered that the American occupying forces actually restricted some senior German Opel executives from returning to their roles at Opel.

One such casualty was Heinz Nordhoff who had headed the all-important Opel Brandenburg truck plant during WWII. Those Opel trucks were so formidable that the German military even instructed Mercedes-Benz to build the Opel trucks instead of their own models. Nordhoff was a rising star who spent pre-war time in America being groomed for a bright future at Opel. But the American forces refused his return to Opel in any capacity other than as a labourer. Major Ivan Hirst of the British forces surrounding Wolfsburg happily welcomed Nordhoff to head Volkswagen. It is highly likely that GM fully understood the capabilities of their former Opel golden boy and recognized what a formidable competitor he would represent at VW. It is interesting to speculate how VW would have fared if Nordhoff had been allowed to return to Opel.

The small car market in post WWII Germany was very difficult to gauge or evaluate based on the type of cars being bought. The microcar offerings included the BMW Isetta, Goggomobil, Heinkel, Messerschmitt and somehow, people bought them. Other makes in the small car sector were DKW, Goliath, Lloyd and even the Ford Eifel and later Taunus 12M. But few of these cars made a dent in VW's armor. This motley crew defied any rational analysis by a GM product planner as to what Germans wanted in a small car.

The above factors indicate why GM did not oppose the market occupied by the Volkswagen until 1962. But what prompted GM to change its mind?

The entry of the Corvair indicated that GM began to realize that there might be a benefit in selling small cars if only to entice young buyers who would graduate in future years to the regular more profitable portfolio of GM cars. This thinking migrated across the pond to Europe. However, GM Overseas Operations (GMOO) had a strategy that would be repeated several times in foreign plants. While the Corvair was a complicated and expensive car to build, the Kadett was simple to build even though it had some innovative features.

The next part of the GMOO strategy was to identify a region of good labour with high unemployment. The chosen area of Bochum had been a coal mining economy that had fallen on hard times. Likewise Ellesmere Port, where the small Vauxhall Viva was built, had the same cheap labour pool. This same strategy has guided GMOO expansion in selection of plants in Spain when they entered the mini car category with the Corsa, but also to Eastern Europe after the fall of the Berlin Wall and other regions such as Brazil, South Korea and China. Only India has defied this winning formula for GM's global expansion.

Louis F. Fourie
West Vancouver, BC
Canada

Editor's Note

This issue marks my first as editor of *Automotive History Review* and I am truly honored to take over the reins from someone as accomplished and respected as *Kit Foster.* I have referred to him as the "Yoda of Automotive History," because there is hardly a topic that he not familiar with. The Society of Automotive Historians would not be what it is today, and might not still be around, without the tireless work that Kit has invested in the organization. I would also like to thank the Publications Committee, as well as the SAH Board of Directors for entrusting me with the editorship of this esteemed publication.

You may have noticed that the look of the magazine has been updated a bit. This was largely due to a new page template needing to be developed, as my system was incompatible with Kit's. This afforded us the opportunity to bring in more graphic elements to illustrate the editorial content.

To that end, we have taken a few liberties and traded the thicker cover for color interior pages and come in at roughly the same cost.

Wherever possible, I would like to incorporate recent photos to illustrate the articles. To my mind, the grainy, faded black and white photos tend to put too much distance between the reader and the subject. By providing modern color photography, we can take away some of the abstract qualities of the topics and bring into focus that these were real cars, real companies and real people who brought these stories to life.

I encourage writers and historians from both the academic and commercial journalism worlds to contribute to the *Automotive History Review.* Well-researched, interesting and relevant material can come from both sides of the aisle and we hope to increase both the diversity of topics and of contributors. Feel free to e-mail me at the address listed on the masthead.

-Don Keefe

Automotive History Review

Winter 2017 Issue Number 57

The Society of Automotive Historians, Inc.
PO Box 1715
Maple Grove, MN 55311-6715
USA