# The Automobile

**The very first Jaguars**
80 years of the leaping cat

**Vintage Revival Montlhéry**
Prewar racers at banked circuit

**From bells to whistles**
The cars of Amédée Bollée *fils*

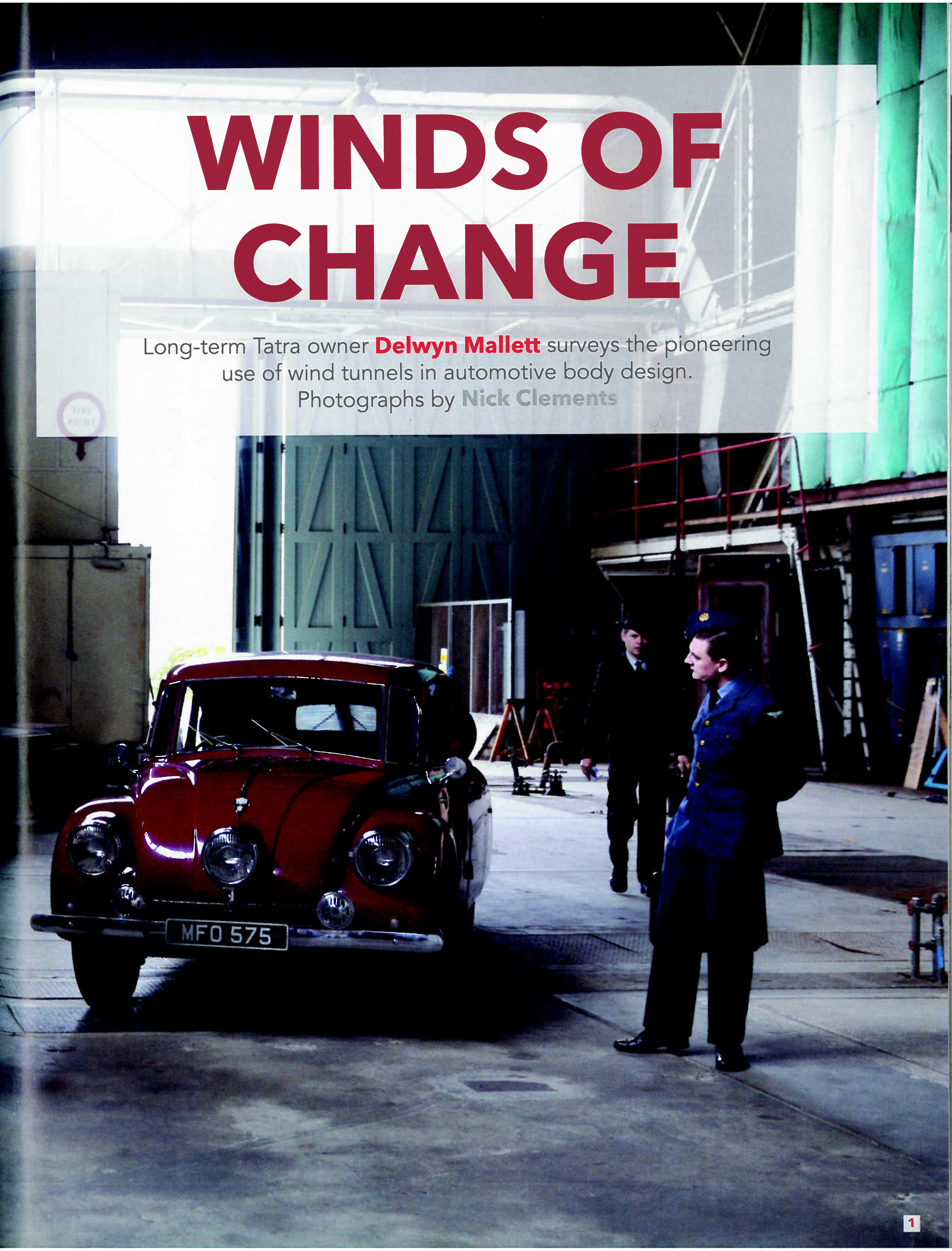
# WINDS OF CHANGE

Streamlining in the '30s

£5.50
July 2015
Volume 33
Number 5

# WINDS OF CHANGE

Long-term Tatra owner **Delwyn Mallett** surveys the pioneering use of wind tunnels in automotive body design.
Photographs by **Nick Clements**



Reversing a Tatra T87 into a tight garage space is no easy matter, due to its tapering streamlined body and almost non-existent rear vision. Ironically the 'difficult' body shape is a direct result of a parking problem pioneer aerodynamicist Paul Jaray was struggling with. His conundrum was on a slightly larger scale: it involved threading 200 metres of Zeppelin into a long, comparatively narrow hangar. Manoeuvering an airship at ground level was far more difficult and hazardous than at altitude, and attempting to 'float' a Zeppelin into its hangar often ended in damage to the fragile envelope. In 1921 Jaray undertook a detailed series of wind tunnel experiments to study the effects of wind direction and airflow over an airship at ground level, simultaneously developing his theories concerning a streamlined aerodynamic form for the motor car.

Wind tunnel research since the latter half of the 20th century has been a given for car designers, but between the great wars it was a new science and a period of discovery, defining fundamentals of airflow over, under, around and through the moving motor car. Although all major car-producing nations made contributions it was engineers from the old Austro-Hungarian Empire who initially led the field.

Four of the seminal automobile engineers of the 20th century were born and educated in or close to Vienna, and during their working lives their ideas and creations intersected regularly. Three were born in the same decade of the 19th century: Edmund Rumpler in 1872, Ferdinand Porsche in 1875 and Hans Ledwinka in 1878. The fourth, Paul Jaray, appeared a decade later in 1889. Their work would change the shape of the automobile.

In their quest to imitate the birds, aspiring aviators had already realised that to study wing shape and function some way of simulating flying conditions was required. The first 'simulator' was the rotating or whirling arm, constructed by mathematician and ballistics expert Benjamin Robins in 1746, which demonstrated that the shape of objects had tremendous influence on air resistance. Sir George Cayley, born in 1773 and considered to be the father of aerodynamics, built his own whirling arm. His extensive experiments led him to identify, define and separate the aerodynamic forces of weight, lift, drag and thrust. Cayley's gliders were the first heavier-than-air machines and, in 1853, the first to fly with a man aboard. The victim, famously, was thought to be his less-than-enthusiastic and soon-to-resign coachman. As early as 1804 Cayley started to research streamlining in relation to ballistics and applied his results to the design of the suspended fuselage (he called it a 'car' or a 'boat') of his gliders. Cayley based his container on the horizontal section of 'a well fed trout', revised later to that of a dolphin. He predicted it would create a 'solid of the least resistance'.

The drawback of the whirling arm was that the object under observation was constantly chasing its own tail and travelling in turbulent air of its own making. In 1871 Frank Wenham, a member of the Aeronautical Society of Great Britain, persuaded the society to fund the construction of the world's first wind tunnel – or, as it was then called, wind channel; 12 feet long and 18 inches square, it generated a 40mph wind by means of a steam-driven fan.

Across the Atlantic, the Wright brothers were following aerodynamic research in Europe closely. They decided to build their own wind tunnel after attaching experimental wing sections to a measuring rig on the front of a bicycle and pedalling frantically; all that effort had proved inadequate. Meticulously measuring more than 200 wing shapes led them to the device that forever ensured their place in history. Flight fever gripped the public imagination after that first momentous event in 1903, and wind tunnels started to blow at institutions and laboratories across the world.

Farnborough's 'wind channel' opened in 1907 and was modeled on that of the National Physical Laboratory, commissioned five years earlier. In the ensuing years more and larger tunnels were built at Farnborough, culminating in the majestic 24-foot version shown in these photographs that was opened officially on 4th April, 1935. That one was capable of accommodating a full-size car, although it was built purely for aircraft research. Racing Jaguars, amongst others, would benefit from testing in the tunnel in the 1950s.

"The T87 yielded a very respectable Cd of 0.36"

In France, Gustave Eiffel, having built the perfect structure to drop stuff from, did precisely that. In 1903 he turned his mind to aeronautics and started testing various shapes by dropping them from his tower attached to a wire that in turn was connected to a measuring device. Drawn deeper into the science of aeronautics, Eiffel constructed France's first wind tunnel adjacent to the tower in 1909, followed by a much more ambitious facility in the suburb of Auteuil, south-west of Paris. Now preserved as a national monument, Eiffel's laboratory quickly established itself as the most important wind tunnel in France.

Early research was, of course, focussed on aircraft design. Although *La Jamais Contente* of 1899, the first purpose-built Land Speed Record car and the first horseless carriage to propel a man at more than 100km/h, had an intuitively 'streamlined' body in the shape of a torpedo or artillery shell, the lack of appreciation of drag on speed was demonstrated by the fact that the driver effectively sat on it rather than in it. More than a few extra km/h could easily have been achieved if the man at the tiller had been smaller, or got his head down.

Possibly the first car to be wind tunnel tested and, if not, certainly one of the earliest, was the *Tropfen-Auto* or Teardrop Car of Edmund Rumpler, who in 1921 engaged the services of pioneer aerodynamicist Ludwig Prantdl to test a model in his tunnel at the University of Göttingen. When, in 1897, the Nesselsdorfer Wagon Works, later to be renamed Tatra, decided to enter the world of the horseless carriage they hired Rumpler as their chief engineer. Working under him was a young mechanic, Hans Ledwinka, who would himself later become chief engineer of Tatra and one of the most influential designers in Europe. In 1902 Rumpler was appointed chief designer for the Adler-Werk where, the following year, he patented the swing axle in their name. He set up his own design consultancy in Berlin in 1906, very much as Ferdinand Porsche would do in Stuttgart two decades later.

Various 'teardrop' streamlined cars were proposed, and even occasionally built, before WW1, but Rumpler's *Tropfen-Auto* was the first to be factory-produced in any significant numbers. Like many engineers of the period, Rumpler was fascinated by flight. After attending the Wright brothers' demonstration at Le Mans in 1908, he threw himself into aircraft design and construction. The *Taube* monoplane was his most successful product, although not designed by him. It was the work of the Bohemian aircraft pioneer Igo Etrich, and as early as 1912 he built a streamlined, closed-cabin version that almost certainly influenced Rumpler's *Tropfen-Auto*.

Rumpler applied for a patent on his radical, mid-engined, transaxle-equipped, independently-suspended car in 1919. A finished version was running in 1920, followed by a whole series of variants, open and closed, until production ceased in 1925. At the core of Rumpler's thinking (the name was of course a giveaway) was the notion that a drop of liquid was the ideal aerodynamic form.

It would be many years before it was demonstrated that the tapered-tail shape so fondly mimicked by early proponents of streamlining was in fact the shape of a *suspended* drop immediately before taking flight. Once it was falling, surface tension pulled the tail in and the drop became an oscillating ellipsoid, alternatively flat and elongated.

The *Tropfen-Auto*, teardrop-shaped in plan only and almost identical in that respect to Cayley's glider 'car' of a century earlier, was remarkably wind-cheating. The closed version even had an aerofoil shaped roof that Rumpler claimed would create lift and thus reduce the weight on the wheels when in motion. At the speeds attainable by road cars of the day, 'lift' had not yet been identified as the nemesis of safe handling that it would eventually become. Like many pioneering ideas, the *Tropfen-Auto* was too radical a departure from convention for the general public. Most ended up as Berlin taxis, with the final ignominy being a pile of them used to fuel a bonfire in Fritz Lang's silent movie epic *Metropolis*.

Nevertheless, there was an important legacy to the short life of the *Tropfen-Auto*. The Benz-*Tropfenwagen* Grand Prix car of 1923 was effectively the chassis of a Rumpler fitted with a cylindrical racing body and an engine of their

**1** Delwyn Mallett's Tatra T87 inside the wind tunnel at the former Royal Aircraft Establishment, Farnborough

**2** Paul Jaray designed the T87's streamlined form


2

4

5

6

own design. Porsche became technical director of the merged Benz and Mercedes in 1924. He familiarised himself with the racer and its merits to the extent that his sensational Auto Union Grand Prix car of the following decade used the same mid-engine, swing-axle layout.

Meanwhile, Jaray was working on his own theories. As a student in Vienna he had enrolled in some of the earliest courses in the science of aerodynamics before furthering his research at the Prague Technical University. In 1914 he became chief engineer of the Zeppelin-owned aircraft builder Flugzeubau in Friedrichshafen, on the shore of Lake Constance, designing seaplanes before switching to the Zeppelin airship works. At Zeppelin, Jaray overturned conventional airship wisdom by proving that a tapering 'teardrop' hull was more efficient aerodynamically than the extended cylinder with pointed ends that then prevailed. Jaray's design was predicted mathematically, but Zeppelin finally acquiesced to his plea for a wind tunnel and in 1916 built him his new toy to play with. The investment would prove to be of incalculable benefit to the future of automobile aerodynamics, if ultimately less so for airships.

With airship construction forbidden in Germany after WW1 under the punitive conditions of the Treaty of Versailles, Zeppelin's thoughts turned to building motor cars and putting Jaray's research into practice. Assisted by Wolfgang Klemperer, Jaray formulated the

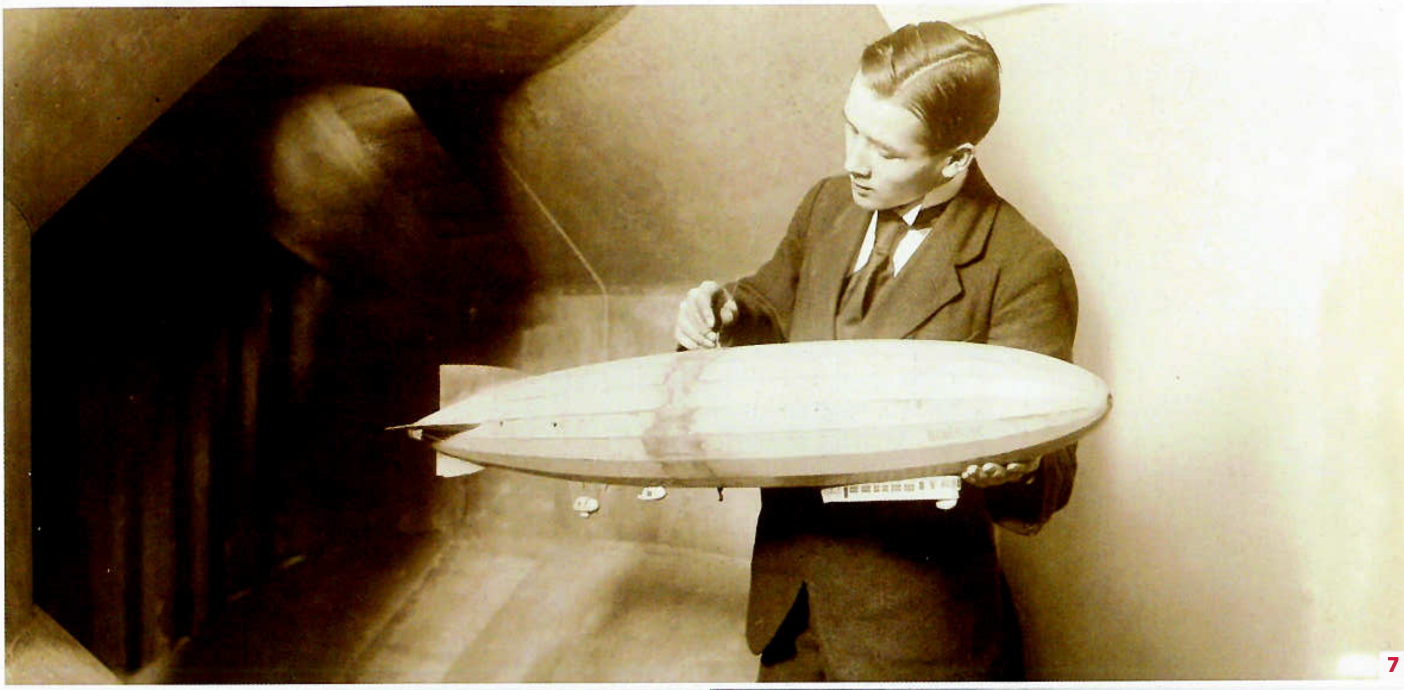
**3** The T87 was one of the few aerodynamic designs of the period to make it into series production

**4** In Volkswagen's wind tunnel in 1979, the Rumpler *Tropfen-Auto* achieved the impressive Cd of 0.28

**5** The Tatra T87 recorded 0.36, worse than the scale-model figure of 0.24

**6** This Kamm design, dating from 1939, only managed 0.39

3




‘ideal’ shape for a truly streamlined car by cutting a Zeppelin horizontally through its centre line to produce an horizontal aerofoil for the mechanical components, with a tapered vertical aerofoil superimposed for the passenger cabin. His first finished bodies were fitted to chassis from Ley, Audi and Dixi. They excited much interest amongst the technical press but left the public unmoved – another case of too far too soon, consumer resistance proving to be far greater than wind resistance. To our eyes Jaray’s first bodies look absurdly cartoonish, being extremely tall and narrow, but one has to remember that this was the age when chassis were high and roofs very high. Gentlemen in those distant days expected to get into their town carriages without stooping or removing their top hats.

In 1923, due to illness, Jaray left Zeppelin and moved across the border to Switzerland, where he founded the Stream-Line Carriage Company to sell and promote his ideas. A host of manufacturers built one-offs designed by Jaray, one suspects more as a sop to fashion than with any real expectation of commercial success. More committed were Adler in Germany and Tatra in Czechoslovakia, but Jaray spent much of the 1930s trying to sell his ideas and chasing companies for infringing his patents. Ultimately his Canute-like efforts were to little avail; he was clearly trying to push back the tide of progress in aerodynamic research. Jaray was uncompromising, too. You had to do the body his way or not at all. This resulted in a series of ‘look-alikes’, losing much of their manufacturers’ individual brand identity.

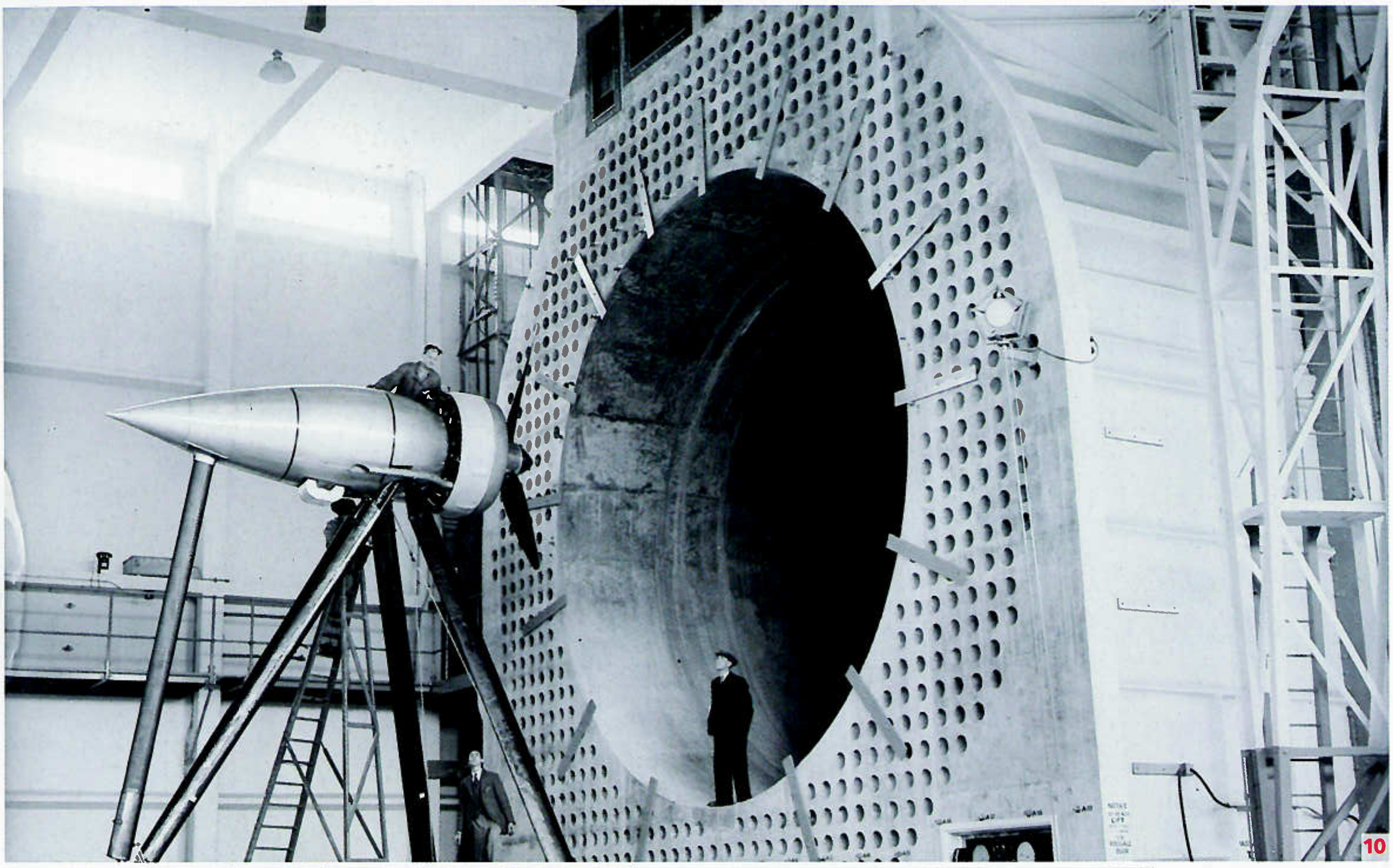
With the advent of the Autobahn system in Germany, streamline frenzy gripped the nation and research gathered momentum, leading to the proposal of an alternative ‘ideal form’ for the motor car. Baron Reinhard von Koenig-Fachsenfeld, while developing a more Autobahn-efficient bus body for a client, discovered that raising the roofline and chopping off the impractically extended tail of the ideal teardrop shape barely compromised the aerodynamics while providing the added benefit of more interior space. Political pressure persuaded Koenig-Fachsenfeld to relinquish his patent to another renowned ‘K’, Wunibald Kamm, whose research continued in the wind tunnel of the Stuttgart Institute. The sloping tail had by now become fashionable, style often supplanting science in execution to the extent that Koenig-Fachsenfeld dubbed the trend ‘pseudo-streamlining’. As a consequence, the blunt-ended ‘K’ shape met with as much resistance as Jaray’s original designs, being considered ugly and unnatural. Only five prototypes were built before the war interrupted development, but it is the Kamm tail with its emphasis on optimising the point of air separation from a subject vehicle’s body that has shaped the cars we drive today.

Hans Ledwinka had left the Nesselsdorf company in 1902. His interest in steam power had not been shared by the management, but at the end of 1905 he was lured back and made head of the automobile division. In 1916, at odds again with the directors, he left for Steyr, the arms company, with a brief to get them into the automobile business. While convalescing after a car accident he formulated a design for a small ‘Volkswagen’, but once again found the management uninterested. Nesselsdorf, by now renamed Tatra, were. Ledwinka returned, for the final time, in 1921 and commenced production of the remarkable lightweight, air-cooled, flat-twin, backbone-chassised independently-suspended T11. He continued to create designs for Steyr but eventually recommended a replacement as chief designer. Step forward Ferdinand Porsche – a man who also harboured a desire to build a Volkswagen.

**7** Paul Jaray (1889-1974)

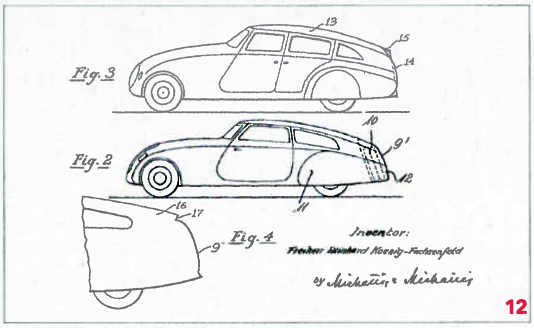
**8** Jaray’s wind tunnel model of his ideal form

**9** Jaray designs on Ley (left) and Chrysler chassis



10

11




12

**10** The 24-foot tunnel at Farnborough opened in the mid-'30s and was used for both aviation and automotive research

**11** Tatra T77 wind tunnel model. The curved windscreen didn't reach production

**12** 'K' tail patent drawing by Reinhard Koenig-Fachsenfeld

By the 1930s 'streamline' design had caught the public imagination and entered mainstream culture, manifesting its clean lines across all kinds of product categories, whether static or mobile. Czechoslovakia, newly formed and proudly independent after the collapse of the Austro-Hungarian Empire, embraced Modernism in all its forms. Ledwinka responded by conceiving a technologically-advanced luxury car fit for the dynamic mood of the streamlined decade, and a suitable companion to the Bauhaus-inspired aesthetic manifesting itself throughout central Europe. Paul Jaray was invited to design the bodywork for the radical rear-engined *tour de force* that Ledwinka had in mind. The resulting T77 of 1934 and the improved T87 of 1936 can justifiably lay claim to having been the first scientifically streamlined cars to make it into series production. The Chrysler Airflow, launched in the same year, although radical in design when compared to contemporary American cars, was ultimately far less rigorous in its application of aerodynamic principles.

Prior to WW2 virtually all wind tunnel research was done using scale models, as there were few tunnels capable of accommodating a full-size vehicle. This has led to some extravagant claims being made for the aerodynamic efficiency of cars of the period, and of the Tatra in particular. Figures of 0.212 for the Tatra T77 and 0.24 for the T87 are often quoted, making them, even by today's standards, phenomenally slippery shapes. In fact, the figures are far too good to be true. The 'low' Cd figures were derived from one-to-five scale models which were known to produce far better results than full-size cars with their turbulence-inducing open seams, window frames, bumpers and wheel wells. No full-size Tatras were tested until 1979 when, out of curiosity, Volkswagen decided to put some classic shapes through their tunnel. The results astonished their engineers. The superficially ungainly 1923 Rumpler *Tropfen-Auto* achieved a quite remarkable Cd of 0.28, significantly lower than that of the T87, which still yielded a very respectable Cd of 0.36. The T87 would have had an even lower figure if Ledwinka had adopted the curved windscreen that Jaray had specified and featured on the original wind tunnel model. (The T87 shown here was tested in the MIRA wind tunnel in 2001 and returned a Cd of 0.37.) A Kamm design of 1939, although more modern in appearance, was not quite as good as the Tatra at 0.39. For comparison the Cd of what is known in the trade as a 'brick' is 1.0. That would be a car something akin to a Model T Ford: curiously, the Cd of a real brick is approximately 2.1. The majority of cars in the 1930s would have had a Cd well above 0.5.

At its launch, the Chrysler Airflow (in fact the DeSoto version) had a Cd of 0.546, which barely supports its name. Further experiments involving deleting appendages, adding an undertray and extending the tail and nose, lowered the figure to 0.316. A curved false screen further reduced it to a creditable 0.238, by which time it resembled a stretched but ugly Tatra. But the Airflow had already succumbed to US consumer apathy and was no more.

Jaray eventually tired of chasing patent pirates and turned his mind to other areas of research in radio, television and aviation. He died in St Gallen, Switzerland, in 1974. ■