# *Lawrence Hargrave - The Forgotten Man*

## *Hudson Shaw*

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For hundreds of years man has watched and envied the apparent effortless flight of birds and on occasions has tried to copy them, usually with disastrous results. It was only when the flight problem was tackled by engineers that progress began to be made toward a solution. Few realise that a major breakthrough toward powered flight was made in Sydney on 31 December 1885 when one of Lawrence Hargrave's model india rubber powered flying machines made a free flight, the culmination of designing and testing many machines of different types.

Hargrave went on to improve the design and range of subsequent machines using as many as 48 india-rubber bands as a power source with an ingenious arrangement of cords and pulleys. Seeking better results with larger machines he turned to compressed air and designed several engines of different types including a radial rotary motor which was to become famous in the first world war.

None of these machines was designed to operate in normal air as Hargrave realised even the normal air was always in motion and when disturbed became a mass of swirls and eddies. Accordingly his tests were made in the early morning when the air was relatively still.

Hargrave at the end of this series of tests decided he would have to design flying machines to operate in the normal disturbed air and commenced a new series of experiments to solve this problem, using kites. He found the answer he was seeking in his tenth kite on 16 February, 1893. This kite consisted of two sets each of nine boxes open at each end and held together by a timber rod. The next slide shows the solution and some of the other models considered. In flight he found the box kite perfectly steady. The result he wanted, a stable flying machine.

He improved both the design and performance of this kite and it reached near perfection in mid 1894. It then consisted of only two large oblong cells, biplane wings with side curtains and all surfaces firmly braced. Hargrave's cellular kites varied considerably with an average length of six to eight feet weight from seven to eight pounds and supporting surface from 40 square feet to 60 square feet. The surfaces were always flat. Hargrave was aware of the greater lift to be obtained with curved surfaces but it was not practical to use curves as the kites had to be folded for transport.

Hargrave announced his invention at a meeting of the Royal Society on 5 August 1896. This paper was also published in several overseas journals. One of the advantages of membership in the Royal Society which he had joined in July 1877, was that he received a number of printed copies of his papers which he was able to post to other workers throughout the world. At the end of each year all papers read to the Society were bound into books and widely distributed. In 1888 for example, 342 copies of the book were sent to libraries, kindred societies and institutions in the other states and thirty one countries, an unrivalled opportunity of having Hargrave's work known throughout the technical world.

In mid 1894 Hargrave realised he now had a reliable and stable supporting surface to which he could add a power source. He decided to test its performance in the strong sea breeze blowing at Stanwell Park where he was then living. He reported as follows:

> On the 12 November a southerly buster came in at 11am of what appeared to be of the right strength. Swain and I carried five kites and the gear to the beach (over the railway line, through two fences and twice across a creek). Flew 37, 25, 39, 40. Forward Starboard booms 39 carried away. Hauled 39 and 40 down (two gentlemen assisting) Replaced 39 with 41. Lower kite secured with gun-tackle purchase to string balance and two bags of sand."
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> Toggled on the sling seat and got aboard with anemometer and clinometer. Swain slacked away the tackle fall to the end. I was then 40 feet from the sandbags and dancing round in an arc of 40 degrees on my toes. The wind veered quite 40 degrees although it was well to the eastwood of SSE. Wind 14.7 mph, spring balance 120 pounds. After a quarter of an hour or so the wind freshened and I went up wind reaching 18.6 mph. Swain read the spring-balance 180 pounds, wind fell lighter and I came down. Wind rather puffy, went up several times not long enough to take a wind reading. A long and strong puff sent me up like a shot and I got a wind reading of 21 mph. Swain read the spring balance 240 pounds. Angle of kite string with the horizon about 60 degrees, my height above ground 16 feet. Wind fell lighter and I came down and with purchase just able haul myself and kites to the mooring. Swaine and I hauled down the four kites with some difficulty."

While the kite experiments were going on, Hargrave was also involved in the production of motion power for a full sized flying machine. Here he was not so successful. His seventeenth engine, a single cylinder steam engine had its cylinder cut from a block of brass. He built seven boilers for this engine. The last one after many setbacks seemed satisfactory but its weight was excessive, so he built another and while it was a success its power output was not adequate. He discontinued this line of work. He then designed a full size powered f/m with his cellular wings and supported on floats with another single cylinder steam engine this time driving flappers instead of a propeller. This project too was abandoned. Hargrave then proposed a waterborn engine platform supported by a string of cellular kites but engine power let him down.

The internal combustion engine was then coming into use but not without its problems. Foremost of these were great heat, vaporising petrol and ignition, none of which was within the experience of an engineer trained in steam power. As light weight I/C engines were not available the would be aviator was obliged to construct his own. Hargrave who had been trained in the workshop of the Australian Steam Navigation Company knew nothing of this new technology and tended to stick with steam. Even here he was confronted with new problems of excessive weight, size and heating of the boiler. These problems did not deter him but they slowed him down. Nevertheless he had built thirty six engines of many different types before admitting defeat.

It is now timely to consider the problems encountered by the astronaut in his operating environment. the major one being balance or stability in both normal and abnormal air. There are three main components involved. The first longitudinal stability which Hargrave resolved with the two separate cells of his kite, one in the front and the other in the rear. The birds solve this problem with their tails.

The second component is lateral stability. The wing of the bird and that of a flying machine are very vulnerable to changes in wind pressure and direction. The birds overcome this problem with an involuntary twisting of their wings which brings one up and the other down until equilibrium is reached. Hargrave's solution was the side curtains in his kite.

The third component is directional stability again an involuntary provision in the bird but in the flying machine by a keel or longitudinal fin. Hargrave's vertical surfaces or side curtains served the same purpose.

Today the kite is regarded as a child's toy. Even in Hargrave's time kite flying was not considered a normal occupation for a grown man, so it was hardly surprising that he was known as the "mad kite flyer"? Only aeronautical experimenters understood the importance of the kite in aviation development. Few now realise the brilliance of Lawrence Hargrave's cellular kite design which was to enable the French to build and fly the first practical aeroplanes. His relatively simple kite had duplicated the three inherent involuntary controls of the birds so that they too became automatic and functioned without intervention. The two remaining flight controls were both manual in the bird and the flying machine. The rudder for steering to the right and left and the elevator for steering up and down.

In hang gliding with a single wing and no tail longitudinal stability was maintained by the pilot moving his body either forward or backward. Lateral stability was maintained by the pilot swinging his legs to one side or the other, a precarious and often dangerous manoeuvre as the deaths at the end of last century of both Lilienthal and Pilcher demonstrated.

I now want to turn to flight developments overseas particularly in France. Clement Ader had built two steam powered monoplanes. The second of these had been credited with a short trip in October 1897. Ader's activities had triggered a spate of interest by his compatriots in France where balloon flight was becoming popular. The motor car had been granted freedom of the roads and this had been a spur to engine development.

One of the several aeronautical experimenters in France was Captain Ferdinand Ferber, an impatient man who after reading of Lilienthal's gliding work became convinced of the future of powered flight. Unfortunately he was in too much of a hurry to get results that he did not devote enough time to discovering what others had done. His whole approach to aeronautics was a trial and error basis, his work although original was poorly carried out even though his efforts were supported by the Aero Club of France.

In 1903 Octave Chanute, a prominent American aeronautical experimenter, visited paris and was invited to address the Aero Club. Everybody was there. Chanute explained his own and the Wright Bros experiments. Chanute's talk was reported in the press with illustrations. Although Chanute's revelations were disbelieved by some they did galvanise others into action. Earnest Archdeacon a wealthy sportsman became the leader of the new movement. He formed an aviation committee in the Aero Club to promote powered flight in France with the object of ensuring the invention of the powered aeroplane would be a French achievement.

Archdeacon realised that the Wright's were well advanced in their experiments and the French had a lot of leeway to make up. He decided to commission the construction of a glider of the Chanute type and sought a builder/pilot. Gabriel Voisin, then twenty-two years of age was recommended to him. He had come to Paris to study architecture.

Gabriel was confident of his ability. From the age of 15 he, with his young brother Charles, had built several boats, an engine powered tri-car and made and flown many kites. About 1898 the brothers had come across an article on Lawrence Hargrave's cellular kites probably his paper read to the Royal Society of NSW on 5 August 1896. They decided to build a "Hargrave".

After long experience with kites they were astonished with the steadiness and lifting power of the "Hargrave". They decided to build a much larger one which took them three weeks, only to have it collapse on test due to structural weakness. They were undeterred and used bamboo instead of deal in their next model. This one was such a success that it remained aloft for several days.

About this time the brothers learnt of the hang gliding experiments of Otto Lilienthal and Percy Pilcher in England. They modified their "Hargrave" by attaching two parallel bars underneath so that they could move backwards or forward to change the angle of attack of their glider. Unsuitable terrain caused them to abandon these experiments.

When Gabriel went to Paris to study architecture Charles began his three year stint of military service. In Paris Gabriel drew his first plan of a flying machine - a glider. He decided to copy the Chanute machine but it would not fly. He rebuilt the wings and substituted a Hargrave tail, for the Chanute one. The glider was an instant success.

This glider was important because it formed the basis of the design of the Voisin powered aeroplanes which first appeared in 1906 and were to remain a major A/C type until the end of the first world war.

Gabriel persuaded Archdeacon to allow him to build a larger glider to operate off water when towed by a fast motor launch. The new machine was to have 538 square feet of supporting surface and be mounted on two floats. "It was a true Hargrave with vertical partitions which gave it the characteristic box-kite look", said Gabriel some years later. Gabriel was assisted in the building by an apprentice from the Astra works, with the sewing done by the girls employed on balloon production. The machine was complete at the beginning of June 1905.

The glider was assembled on the banks of the river Seine near Paris. The test flight was to be made on the stretch of the river between the Billancourt and the Sevres bridges, towed by "La Rapière", a 150 HP racing boat. At 3.00pm the aircraft was towed to Billancourt bridge. Gabriel was to comment some years later "My machine of June 1905 was magnificent, strongly built with an appearance of steadiness I would like to see in the latest airliners.

"I made fast my towing cable to the longeron aft on forward wing cell. I took up my position astride of my small saddle and gave the pre-arranged signal to Archdeacon who was on board La Rapière waiting, with our recording dynamometer set in the towing cable. The air speed indicator was on my left, I had the controls ready. "

"I waited for a time (after the start) then applied the elevator. My lovely glider instantly left the water. In a few seconds I was as high as the poplars along the quay. I went along without oscillation either in pitch or roll. We were approaching Sevres bridge. La Rapière slowed and I alighted on the water without incident."

"Archdeacon recorded the tractive effort and I read the speeds. I was so sure of success that I did not at the time appreciate the importance of what had been done. We had in fact resolved three problems of the utmost importance:

1 The stability of the craft

2 Its behaviour at take-off and touch-down

3 The power needed

"The trial attracted little attention - an article in the "Le Martin" the next day did record my performance. For the first time in the world in the presence of the public, without the aid of ascending air currents, a hydro-aeroplane had left the water and returned to it after a flight of 2000 feet, carrying a pilot and in full control of its manoeuvers the whole powered by an external mechanical power source."

"Everybody in Paris who was interested in heavier than air craft had been at our trial which had been photographed." Santos Dumont had on that day decided to switch his aeronautical experiments from dirigibles to powered flying machines. Santos was to make the first engine powered flight in public of 72 feet on 12 November 1906 in a huge Hargrave "box kite".

Louis Blériot ordered on the spot a similar machine. He asked for a curvature of the wings of one in ten. Voisin explained to him that large cambers deprive kites of their lateral stability but he would not listen.

Gabriel Voisin encouraged by his experience with his waterborne inherently stable Hargrave cellular kite glider built and tested with his brother Charles another glider with a Hargrave type cellular tail. Successful flights encouraged the brothers to design and build in 1906 a large powered biplane, the initial design of which was maintained basically unchanged until 1910. It was inherently stable with its biplane wing and Hargrave cellular tail.

It had a wheeled undercarriage and a two bladed pusher propeller driven by a 50HP Antoinette engine, and a Maxim type forward elevator. Initial tests of this machine consisted six take-offs in March and April 1906, the last being a hop-flight of 196 feet.

The first Voisin was ordered by Henry Kafferer. Subsequent machines were supplied to Leon Delagrange, Hone-Brabayon, Henry Farman and many others. The French aviation movement which had been so slow to take off, due largely to time wasted in attempting to copy the Wright Bros, was now under way and was to be seen in its full flowering at the great aviation meet held at the ancient city of Reimes in 1909.

The true significance of the Voisin aircraft was that they were developed independently of the Wright machines so much so that the aeroplane would have developed in much the same way had the Wrights never lived. The Voisin machines were easy to fly, an owner could teach himself to fly and many did just that. Its other great advantage was its stability and therefore its safety in flight both features due to the use of Hargrave's supporting surfaces.

While Hargrave realised the genesis of his work in the Voisin machines and those of Santos Dumont, Blériot and most of the other experimenters he had made no restriction but had actually encouraged others to make use of his ideas. He had realised early in his experimental work that only by sharing ideas would the path to powered flight be shortened.

His major share in the final triumph was not recognised but Hargrave had his own rewards. He had seen the progressive use of his ideas and his faith in powered flight achieved in his lifetime. His contributions had been immense. We possess his detailed records and drawings and a representative collection of his work.

He was anxious that his models should be preserved and placed on exhibition as a spur and incentive to others. He gave his collection of early flying machines to the Museum of Applied Arts and Sciences in 1890 on the condition they would always be on show to the public. This undertaking was faithfully kept for some ninety years. When the remnants of the huge collection he had given to the Science Museum at Munich in 1910 were generously returned and given to the museum by QANTAS in the 1960s they were displayed in a magnificent memorial court in the museum with funds under subscribed by the public in the 1920s for a Hargrave memorial.

When the contents of the old museum were transferred to the Power House the authorities refused to reinstate the "Lawrence Hargrave Memorial Court" and unbelievably stored this unique collection away in their vaults where it has remained for some twelve years, to preserve for future generations, in defiance of all logic, Hargrave's wishes and the wishes of the public who subscribed in the 1920s for a Lawrence Hargrave memorial.