

Os Voos de Santos Dumont e Wright sob o Ponto de Vista da Engenharia Aeronáutica.

Fernando M. Catalano, PhD
Departamento de Engenharia Aeronáutica
Escola de Engenharia de São Carlos



Quotes

Airplanes are interesting toys but of no military value.

— *Marshal Ferdinand Foch, professor of strategy, Ecole Superiure de Guerre, 1911*

Inventions reached their limit long ago, and I see no hope for further development.

- *Julius Frontinus, 1st century A.D.*

Heavier-than-air flying machines are impossible

- *Physicist, Lord Kelvin, President, Royal Society, [ENGLAND] 1885.*

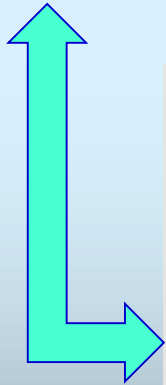
All attempts at artificial aviation are not only dangerous to life but doomed to failure from an engineering standpoint.

— *editor of 'The Times' of London, 1905*



Lillienthal

“O número de projetos sem sucesso neste domínio [Aeronáutica] é enorme. Contudo, ao longo dos tempos, desde o lendário Daedalus a Leonardo da Vinci, as maiores mentes já investigaram este problema. Não há outro desafio mais atraente para a humanidade do que este ... para o homem, cujos trens são mais rápidos que o cavalo de corrida mais rápido e cujos navios, não obstante a sua gigantesca dimensões, podem manobrar com tanta facilidade e rapidez, de modo a zombar do peixes em sua arte. Não será que ele vai ser capaz de seguir os pássaros no céu? ”



Ludwig Boltzmann

Geração de forças
aerodinâmicas



propulsão

Solução
do voo
mais
pesado
que o ar

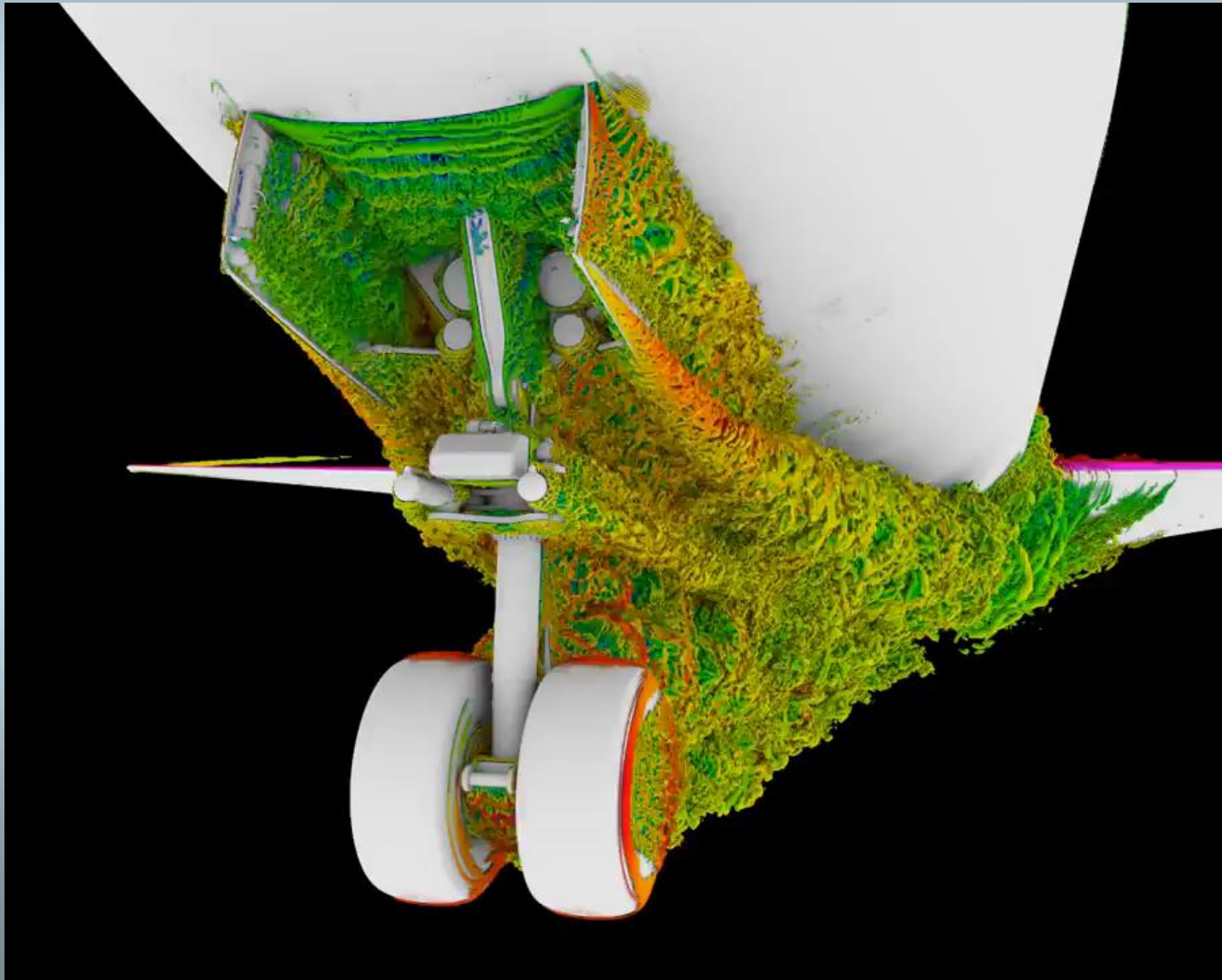
Boltzmann and the Art of Flying

Silvio R. Dahmen

Universidade Federal do Rio Grande do Sul

CFD + CAA based on Lattice Boltzman theories

CAA computation Aeroacoustics



Literatura da época

George Cayley
"Governable
Parachute" Glider -
1852

Lilienthal, Otto.
Birdflight as the
Basis of Aviation.
Berlin 1889

HYDRODYNAMICS

BY

HORACE LAMB, M.A., F.R.S.
PROFESSOR OF MATHEMATICS IN THE OWENS COLLEGE,
VICTORIA UNIVERSITY, MANCHESTER;
FORMERLY FELLOW OF TRINITY COLLEGE, CAMBRIDGE.

CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1895

[All Rights reserved.]

F.W.
Lanchester
1907

Mechanics' Magazine, MUSEUM, REGISTER, JOURNAL, AND GAZETTE.

No. 1526.] SATURDAY, SEPTEMBER 25, 1852. [Price 3d., Stamped 4d.
Edited by J. C. Robertson, 56, Fleet street.

SIR GEORGE CAYLEY'S GOVERNABLE PARACHUTES.

Fig. 2.

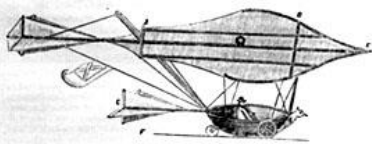
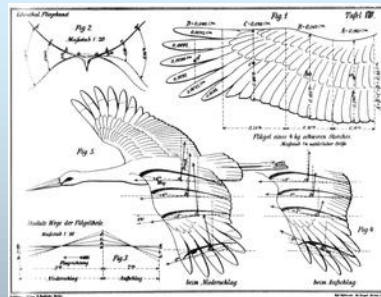
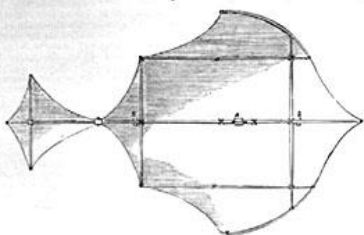


Fig. 1.



Horace Lamb
Hydrodynamics
1895

AERODYNAMICS

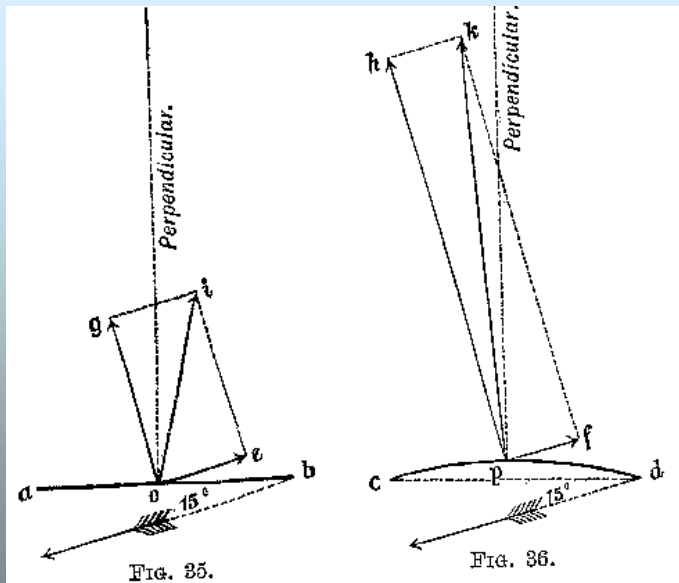
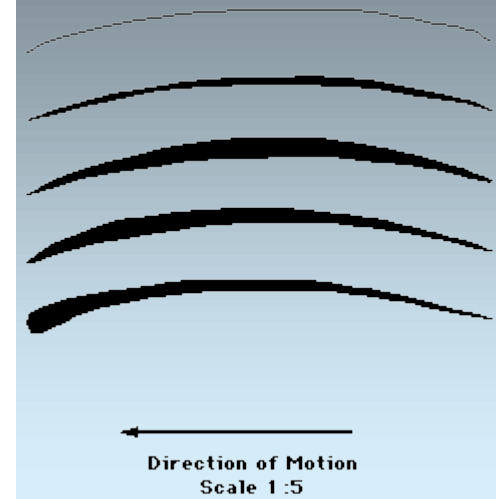
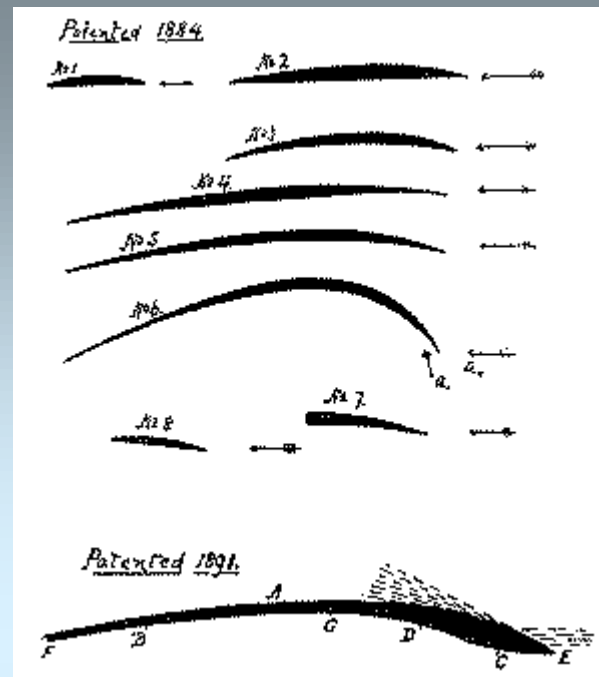
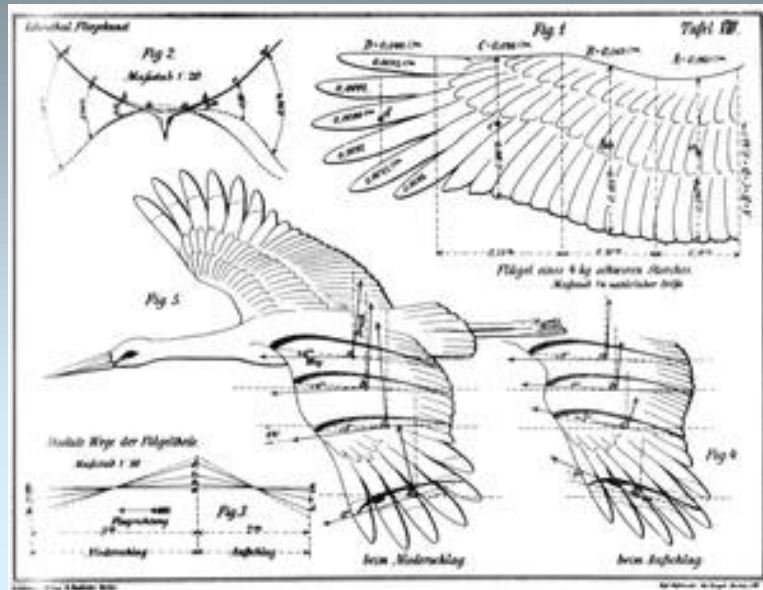
CONSTITUTING THE FIRST
VOLUME OF A COMPLETE
WORK ON AERIAL FLIGHT

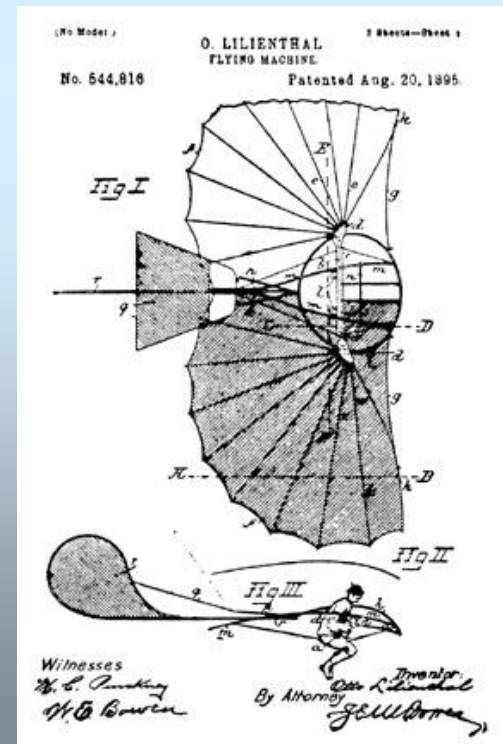
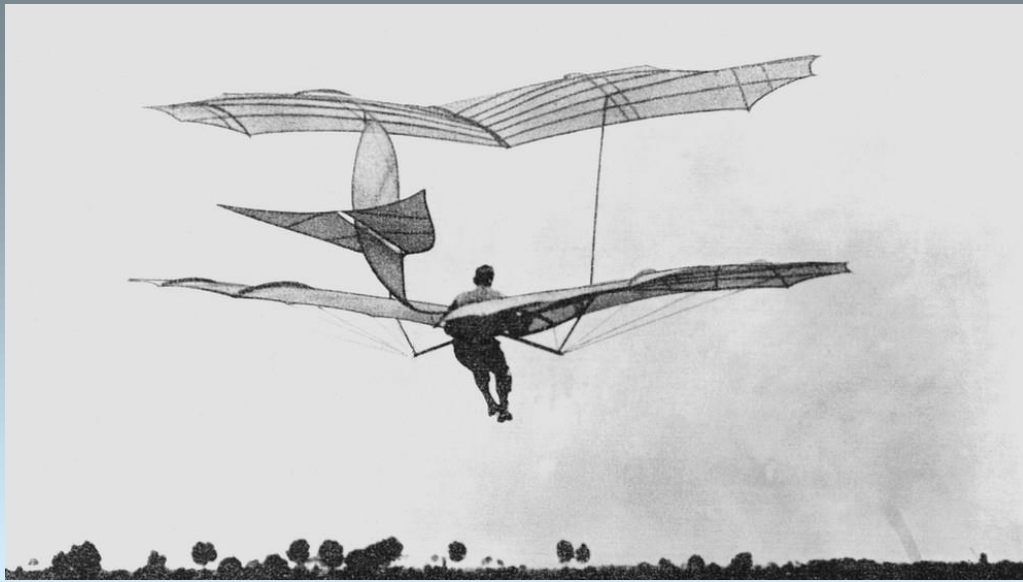
BY
F. W. LANCHESTER

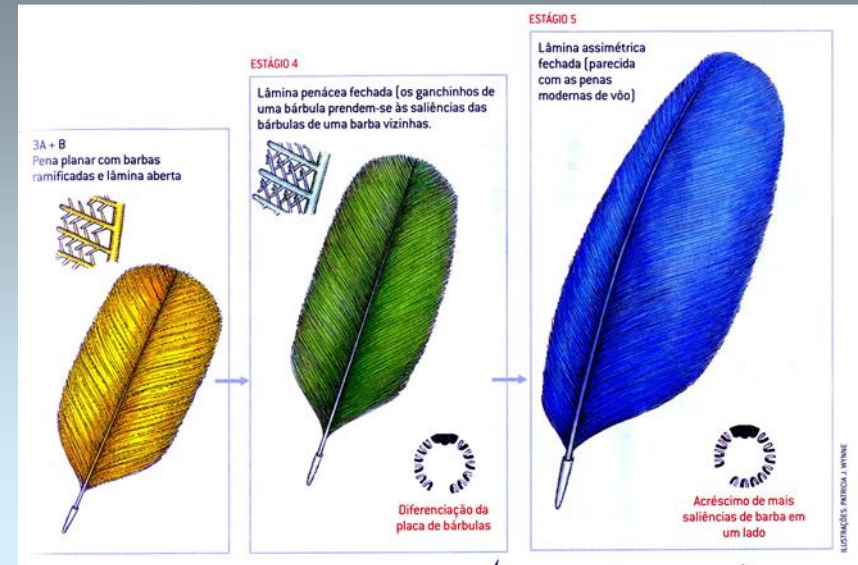
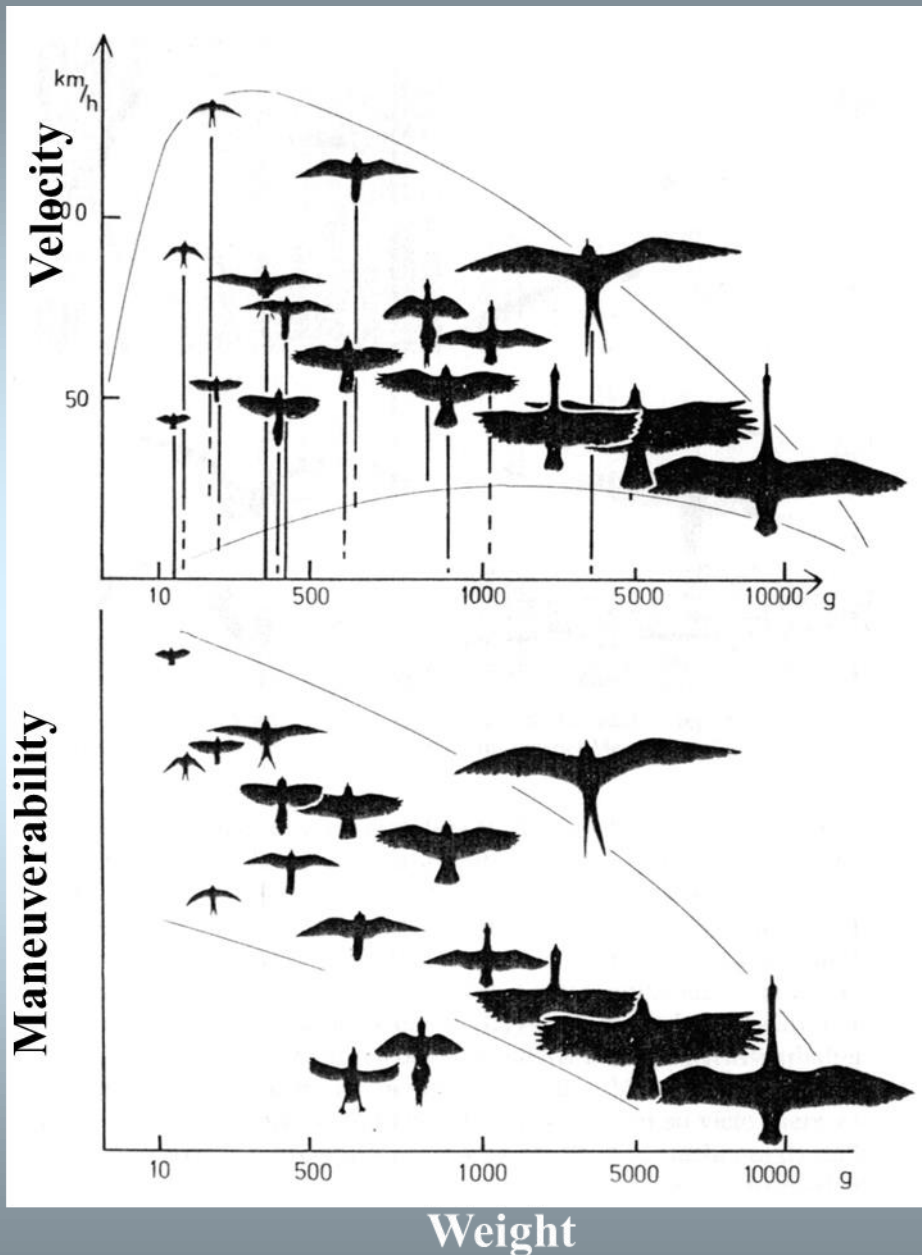
*With Appendices on the Velocity
and Momentum of Sound Waves,
on the Theory of Steering Flight, etc.*

LONDON
ARCHIBALD CONSTABLE & CO. LTD.
ORANGE STREET LEICESTER SQUARE
1907

Otto Lilienthal



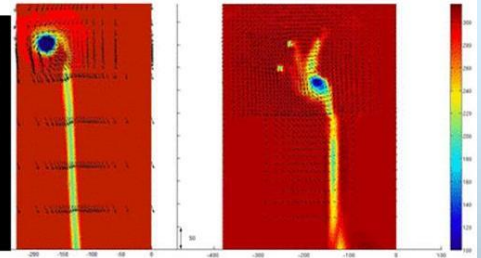
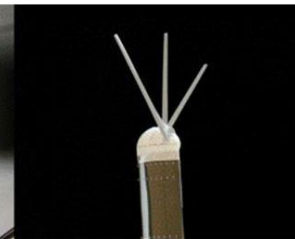
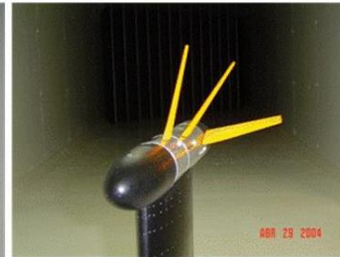




- Contribuições até hoje:
- Aeroacústica
- Redução do arrasto
- Morphing wing
- Flow control



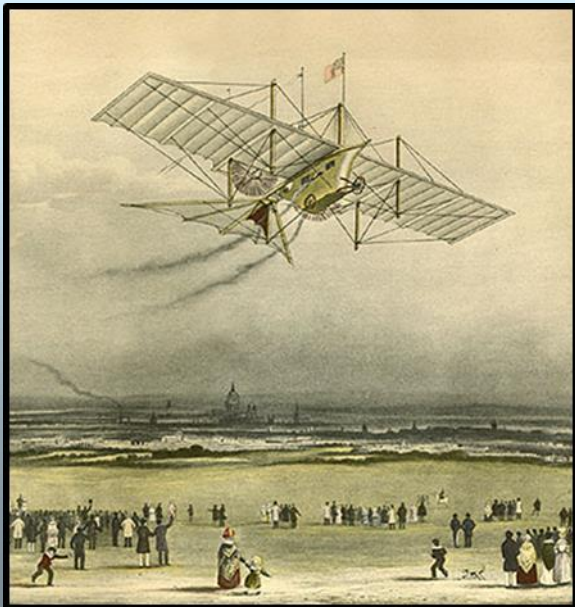
Adaptatives Multi-winglets



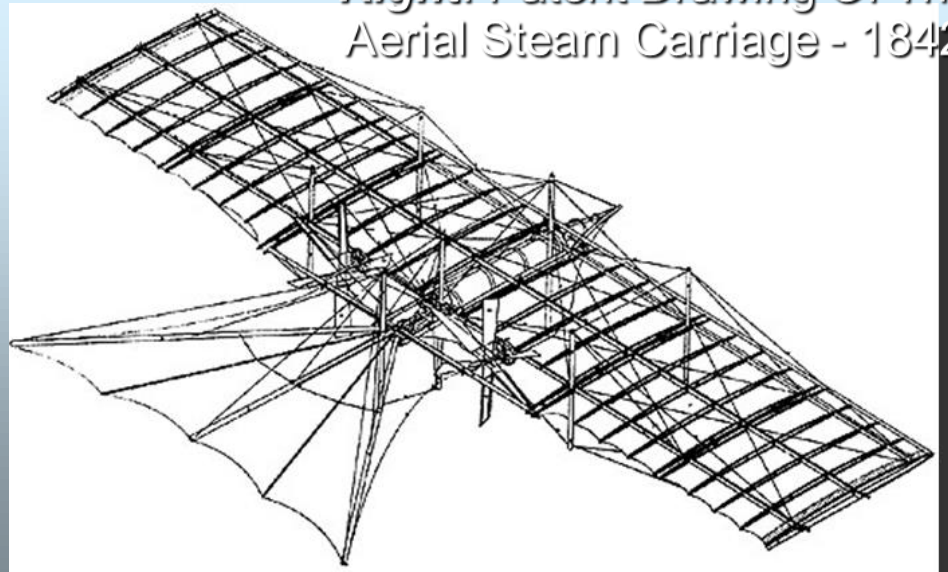
Voo em formação

Samuel Henson - 1840

Os inventores britânicos John Stringfellow e William Samuel Henson, colaboraram para criar o primeiro modelo de um avião em 1840. Eles chamaram este modelo a Transporte Aéreo a Vapor. Este modelo era alimentado por um motor a vapor e lançado a partir de um cabo. Este modelo tinha hélices, fuselagem, trem de pouso com rodas e controle de voo por meio de um elevador traseiro e leme. O modelo não foi bem sucedido porque não conseguiu subir. No entanto, este modelo foi o primeiro a se assemelhar às aeronaves modernas atuais.



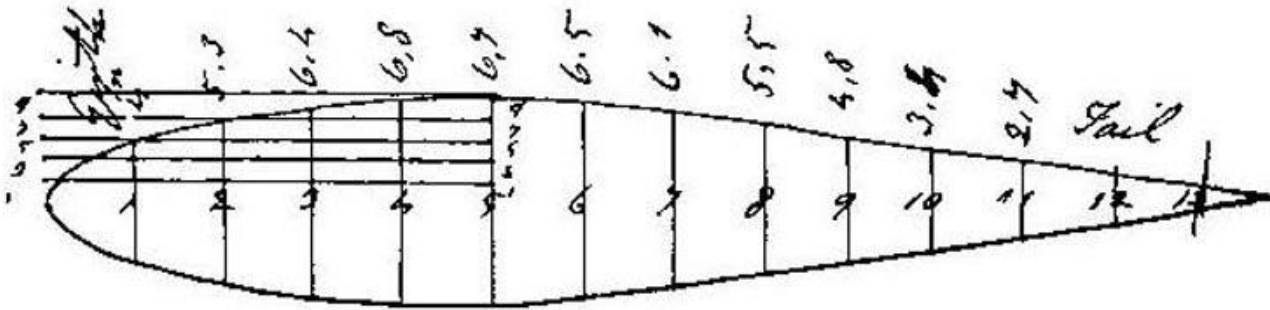
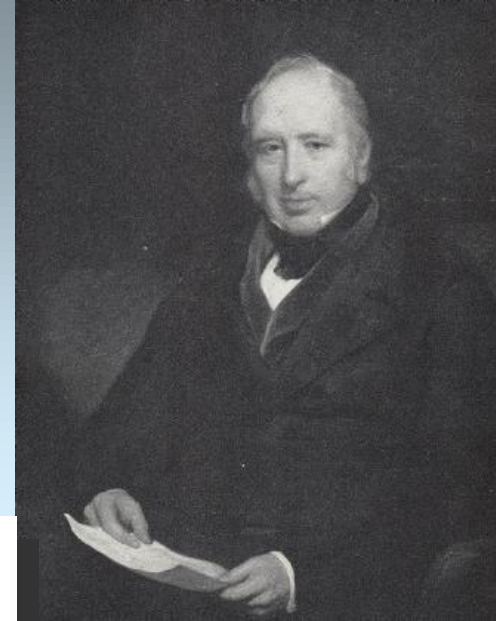
*Right. Patent Drawing Of The
Aerial Steam Carriage - 1842*



Sir George Cayley

I am apt to think that the more concave the wing to a certain extent, the more it gives support, and that for slow flights a long thin wing is necessary, whereas for short quick flights a short broad wing is better adapted.

”

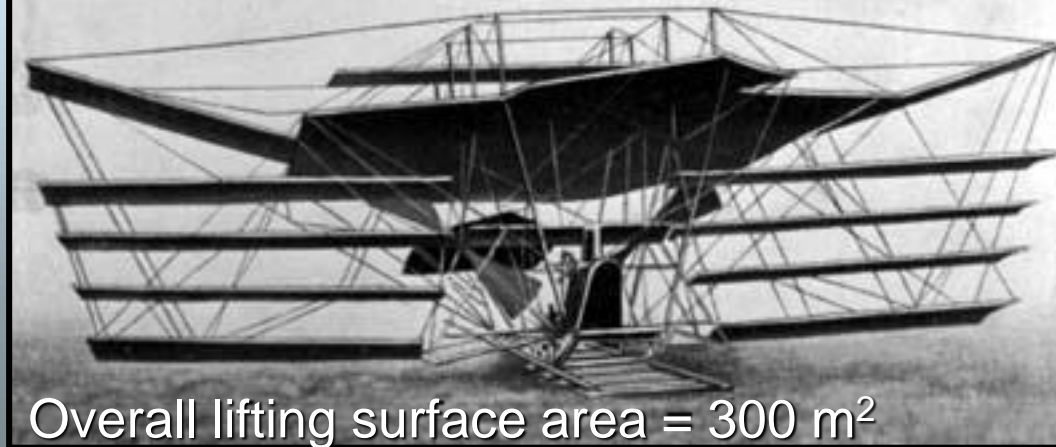


A drawing of an airfoil (streamlined body) based on the contour of a trout. This idea failed to influence later scientists, until aerodynamic theories in the early 20th century evidenced the benefits of thick airfoil sections. (This shape is not too different from a symmetrical NACA airfoil).

Hiram Stevens Maxim - 1894

Hiram Maxim fez uma fortuna com sua invenção da metralhadora Maxim, e ele usou um bom bocado de que a fortuna para explorar vôo mais pesado que o ar. Maxim começou seus experimentos aéreos na Baldwyns Park, Inglaterra, no final dos anos 1880, levando à construção em 1893 de seu biplano enorme como um Test-Rig, que pesava cerca de 3,0 ton. Com dois motores a vapor cada um produzindo 180 cv, acionando duas hélices com 5,5 metros de diâmetro cada. Uma vez que o dispositivo foi concebido para ser um veículo de teste, tentativa de voo foi realizada num cabo, impedindo-a de subir mais do que uns dois metros.

The Maxim Pentaplane Test-Rig With All Lifting And Control Surfaces Attached - ca. 1894



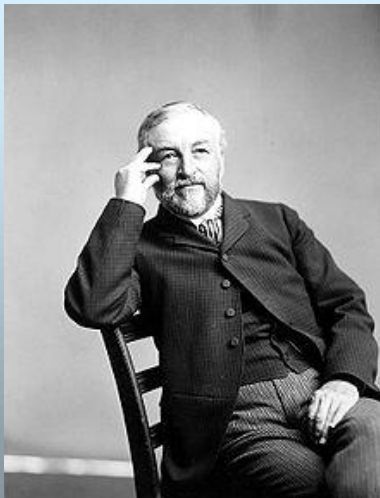
The Maxim Biplane Test-Rig, Track and Building - ca. 1894



Fonte Bento Matos

Samuel P. Langley

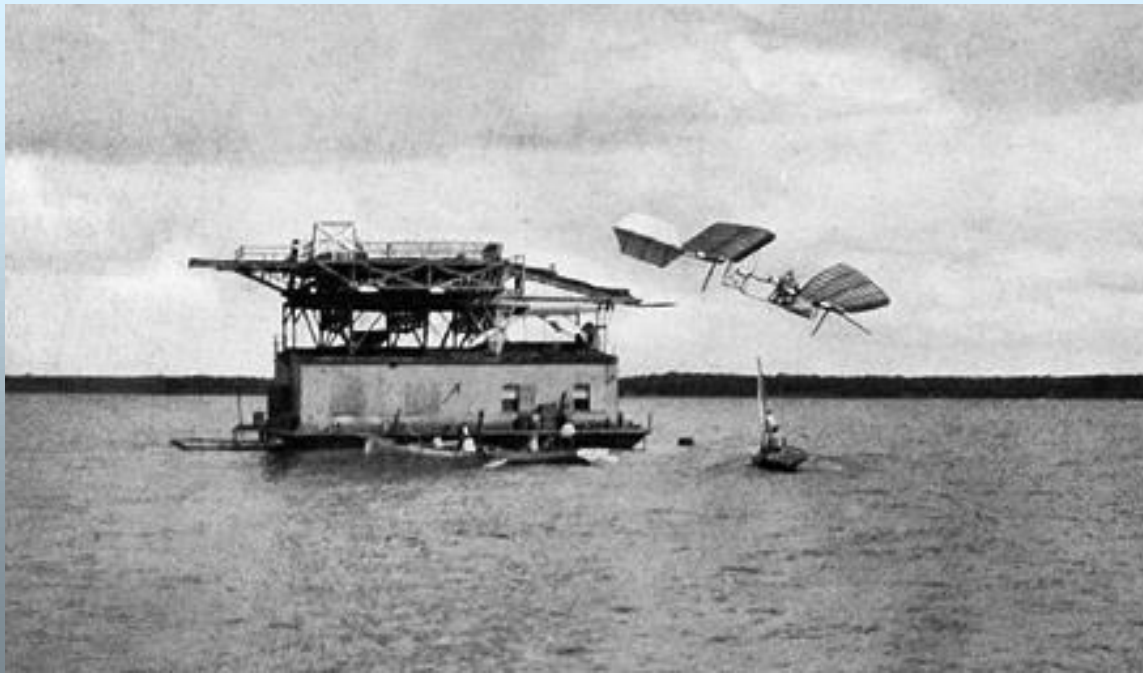
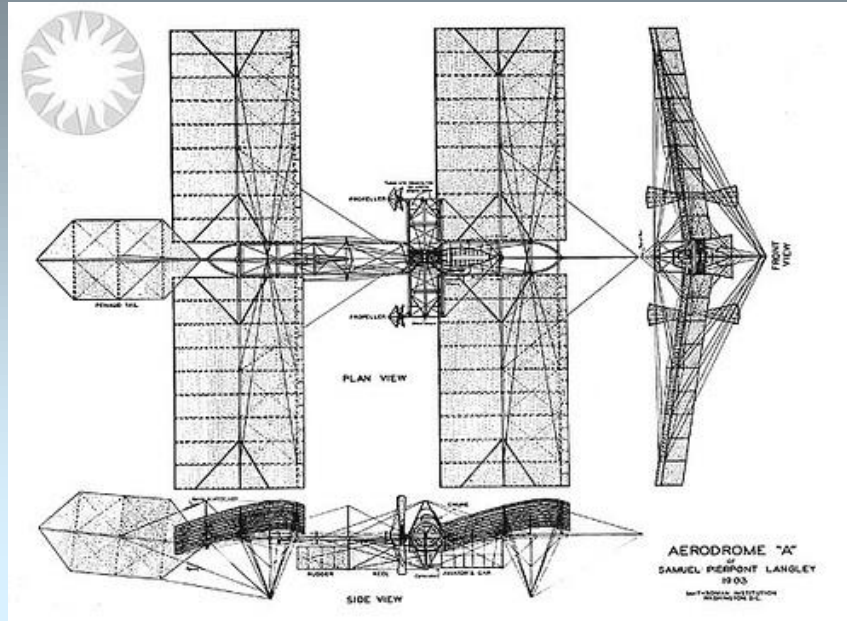
Em 11 de novembro de 1896 o seu modelo número 6 voou mais de 5.000 pés (1.500 m). Em 1898, com base no sucesso de seus modelos, Langley recebeu uma doação de departamento de guerra de US \$ 50.000 e US \$ 20.000 a partir do Smithsonian para desenvolver um avião pilotado, que ele chamou de um "Aeródrome" (oriundo de palavras gregas traduzido aproximadamente como "corredor de ar") . Langley contratou Charles M. Manly (1876-1927) como engenheiro e piloto de testes. Quando Langley recebeu a notícia de seu amigo Octave Chanute do sucesso dos irmãos Wright com o seu planador de 1902, ele tentou reunir com os Wrights, mas eles educadamente recusaram seu pedido.



Langley ?

S Dumont

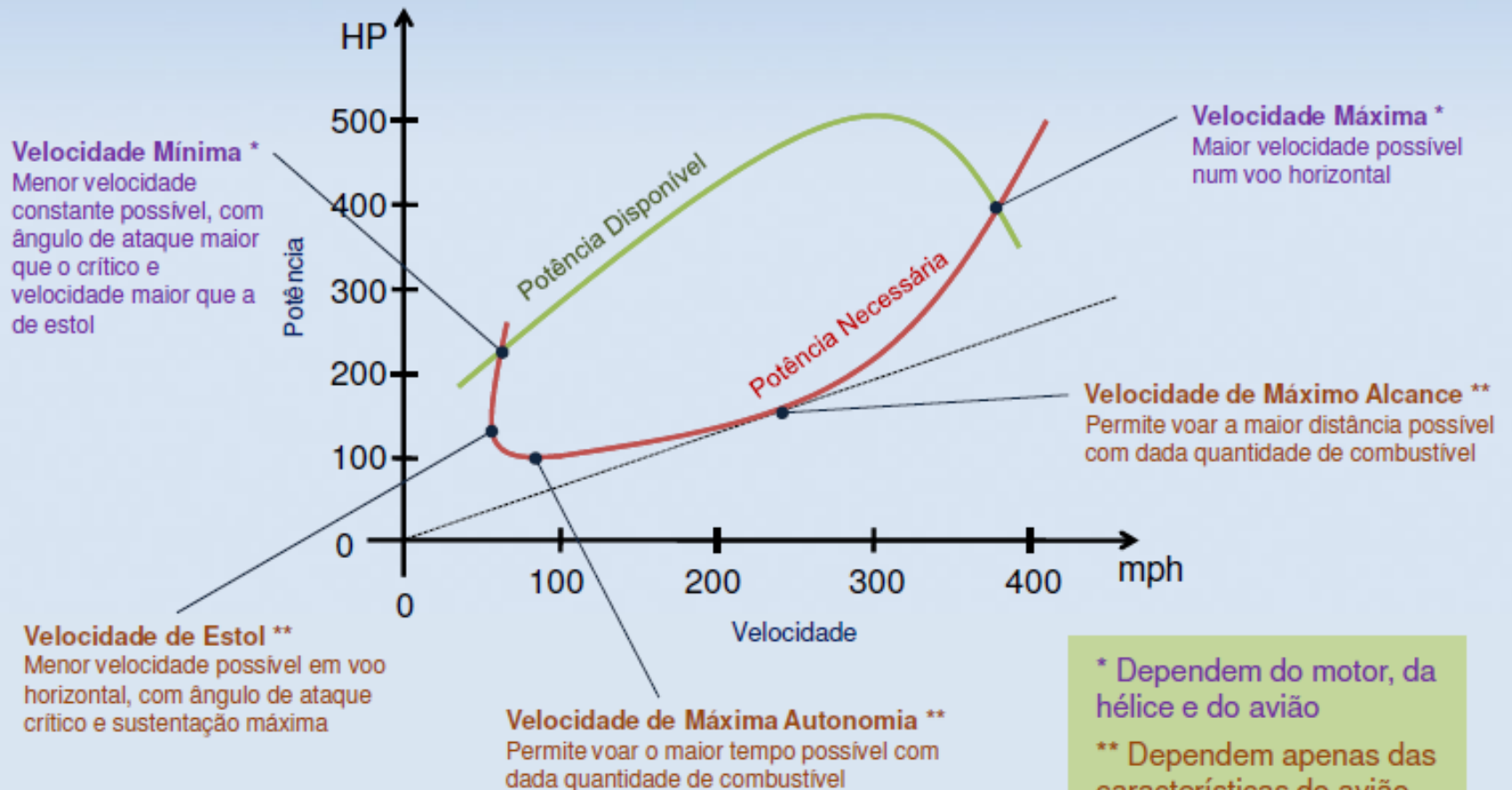
Samuel P. Langley



Langley's Aërodrome No. 5 in Flight, May 6, 1896
From instantaneous photograph by Alexander Graham Bell

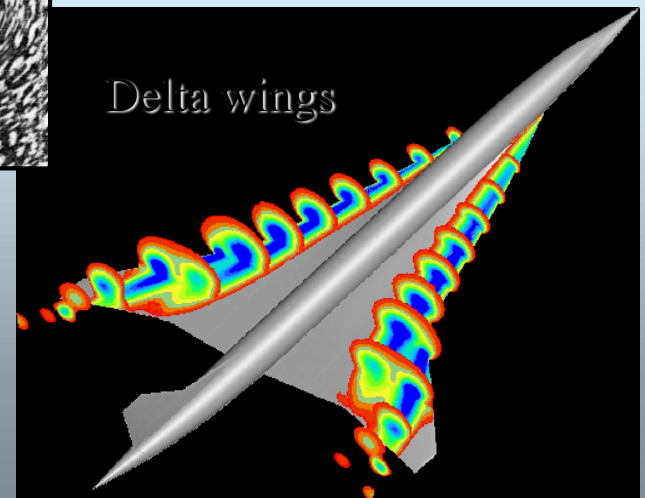
Samuel P. Langley

Voo Horizontal



Langley was the first to indicate the power x speed curve

Creation of Lift

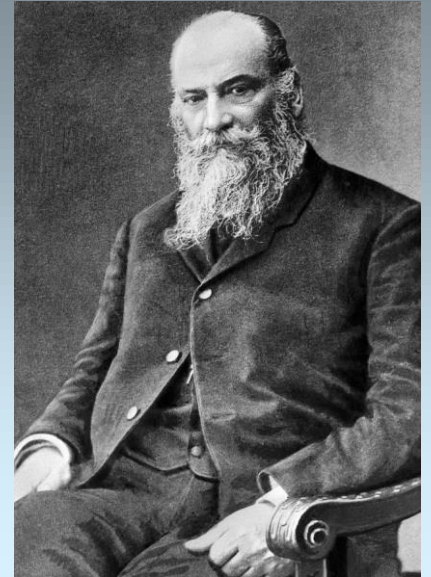


Creation of Lift

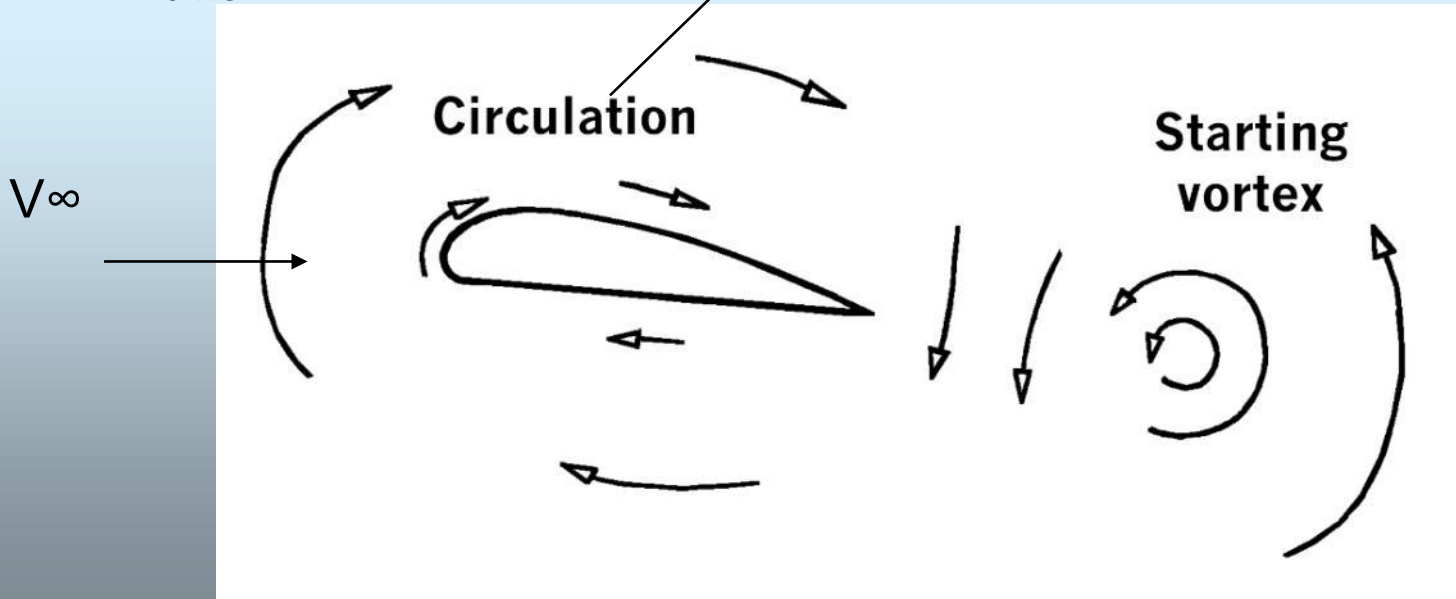


Kutta

$$L' = -\rho_{\infty} V_{\infty} \Gamma,$$



Joukovski



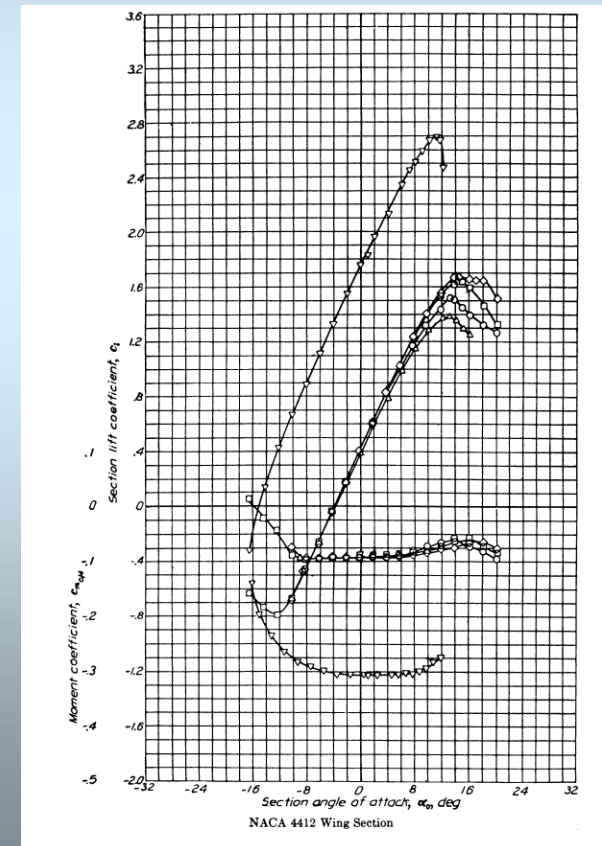
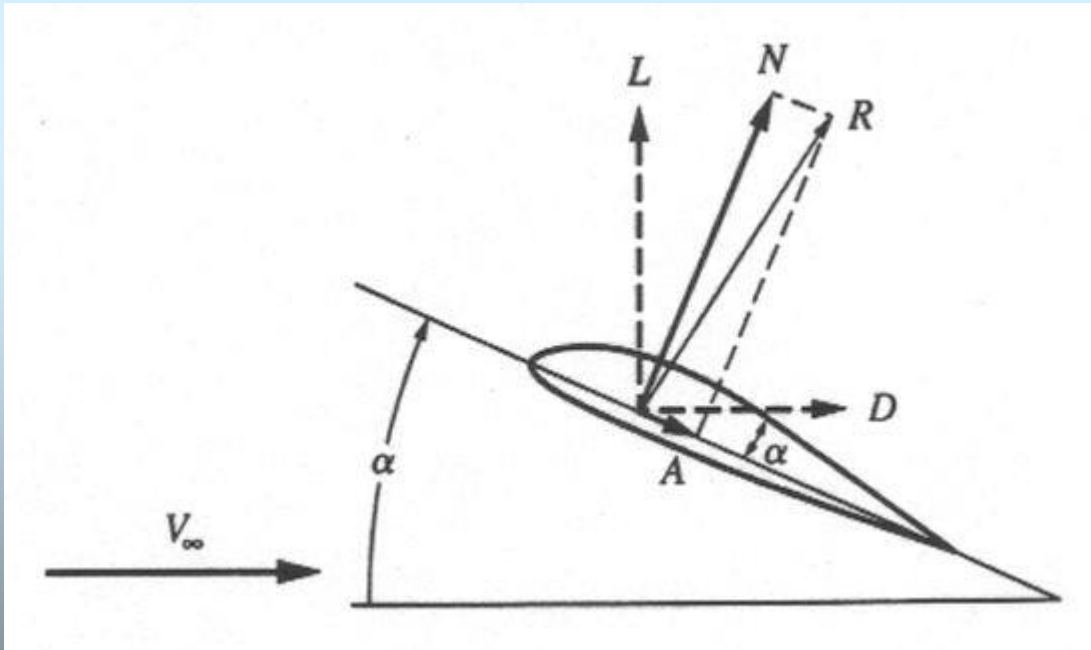
Aerodynamic Coefficients

$$C_L = \frac{F}{\frac{1}{2}\rho V^2 S}$$

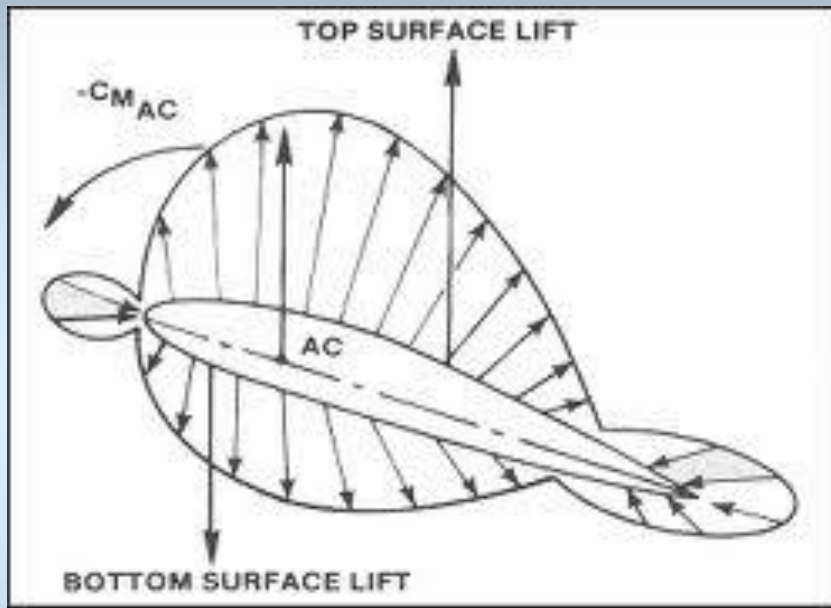
Lift coefficient

$$C_D = \frac{D}{\frac{1}{2}\rho V^2 S}$$

Drag coefficient



Aerodynamic Coefficients



$$C_m = \frac{M}{\frac{1}{2} \rho V^2 S c}$$

Centro aerodinâmico : local onde $C_m = \text{cte}$ independentemente de α

Centro de pressão: local onde $C_m = 0$ e depende de α

A questão da aeronavegabilidade e a dinâmica de voo



- Estabilidade estática longitudinal
- Ponto neutro
- Centro aerodinâmico
- Centro de pressão
- Margem estática

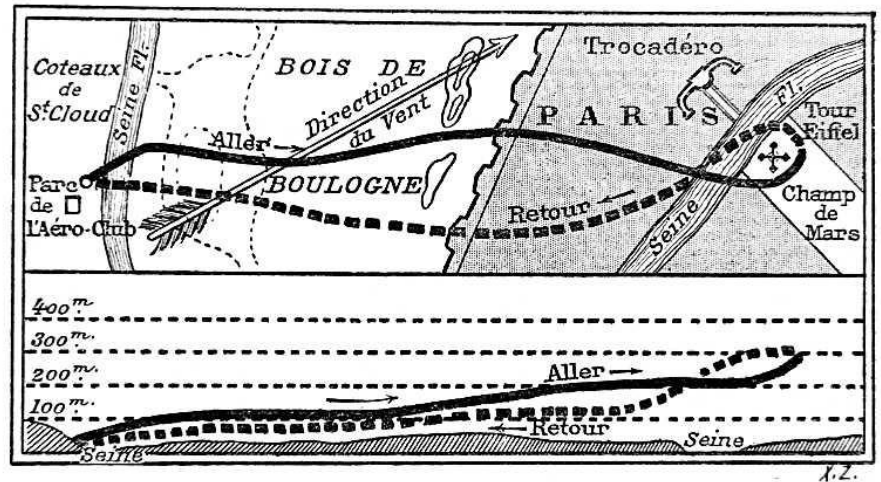
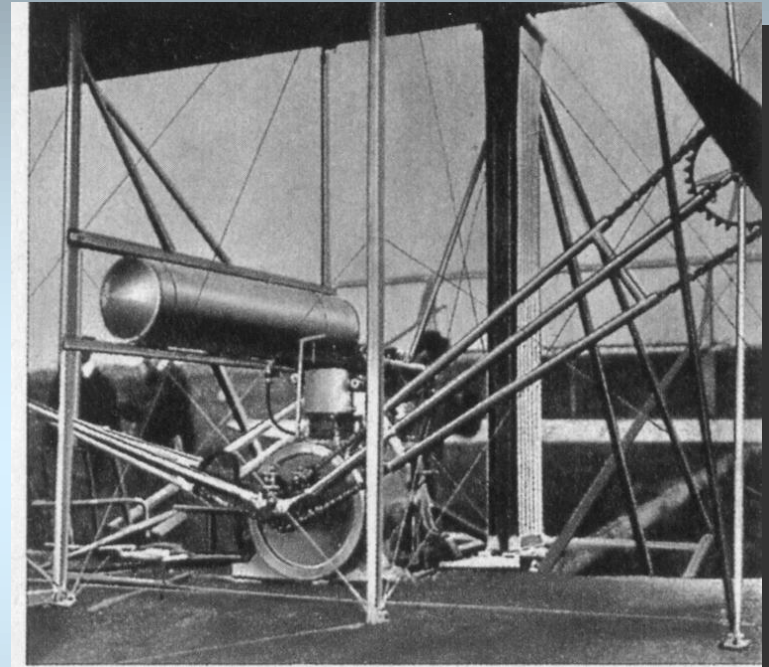
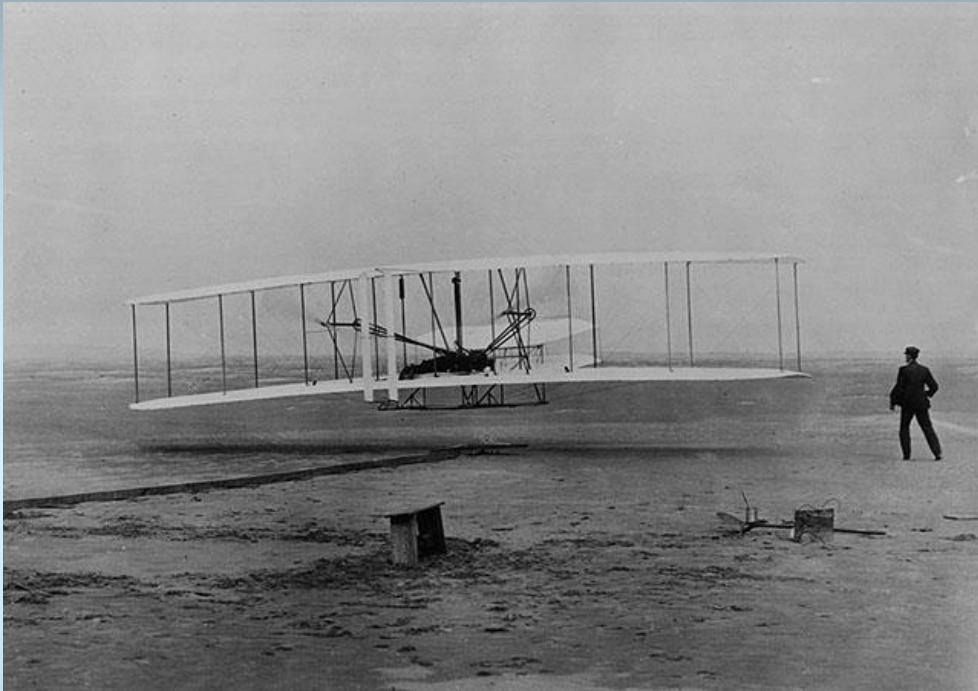


FIG. 32. — CARTE EN PLAN ET EN HAUTEUR DU VOYAGE DE SANTOS-DUMONT (PRIX DEUTSCH, OCTOBRE 1901).

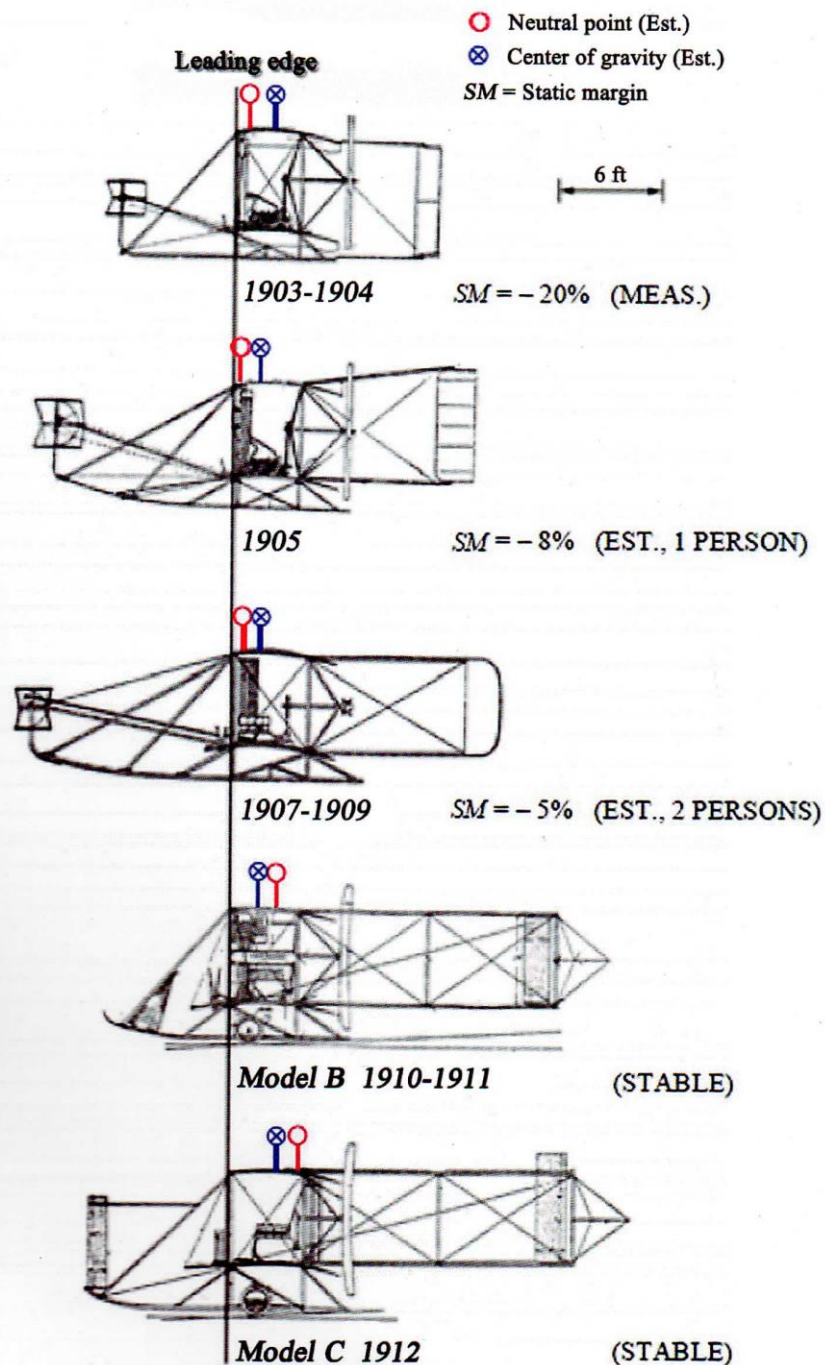
Santos Dumont / The Wright Brothers



- **1903 Flyer-1** was driven a home-made 12-hp engine, which had a weight of 80 kg
- **1904 A 21-hp engine** equipped the Flyer-2 flying machine
- **1909 Flyer-B** was powered by a 36-hp engine

Fonte Bento Matos

1903 flights (?) with a 29mi/h incoming wind, other flights with a catapult
(46.7Km/h)



- Todos os Flyers incluindo o IV eram instáveis
- Flyer I e II o duplo canard mudava de camber .
- A potencia disponível era insuficiente para decolagem.
- Flyer III usava catapulta.
- Flyer IV de 1907 foi montado na França e era ainda sem potência e não cumpria os requisitos prometidos.
- Flyer IV de 1908 usava motor francês desempenho excelente porém instável.
- Model B e C totalmente ultrapassado pelos modelos Franceses, Ingleses e Alemães

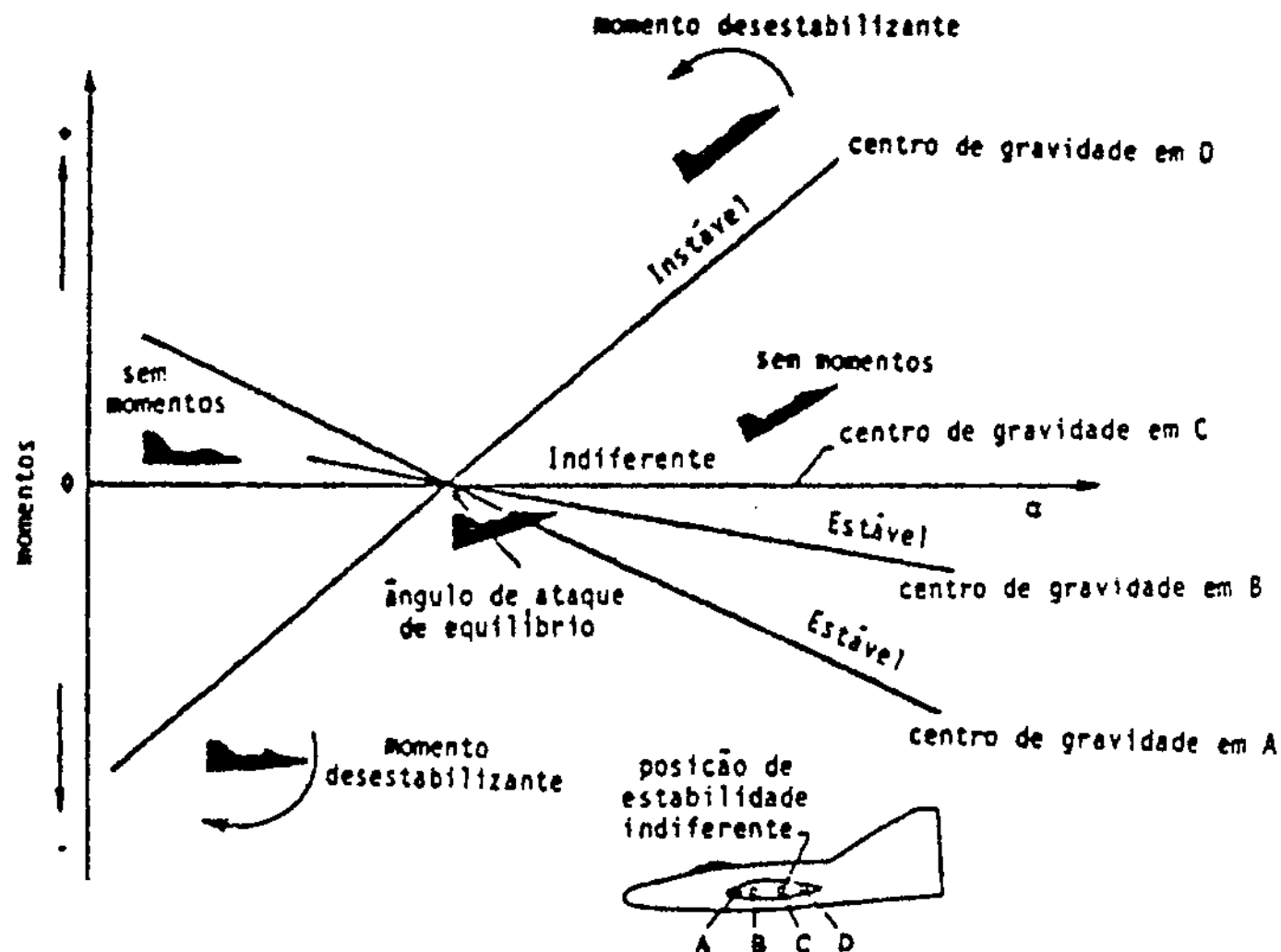
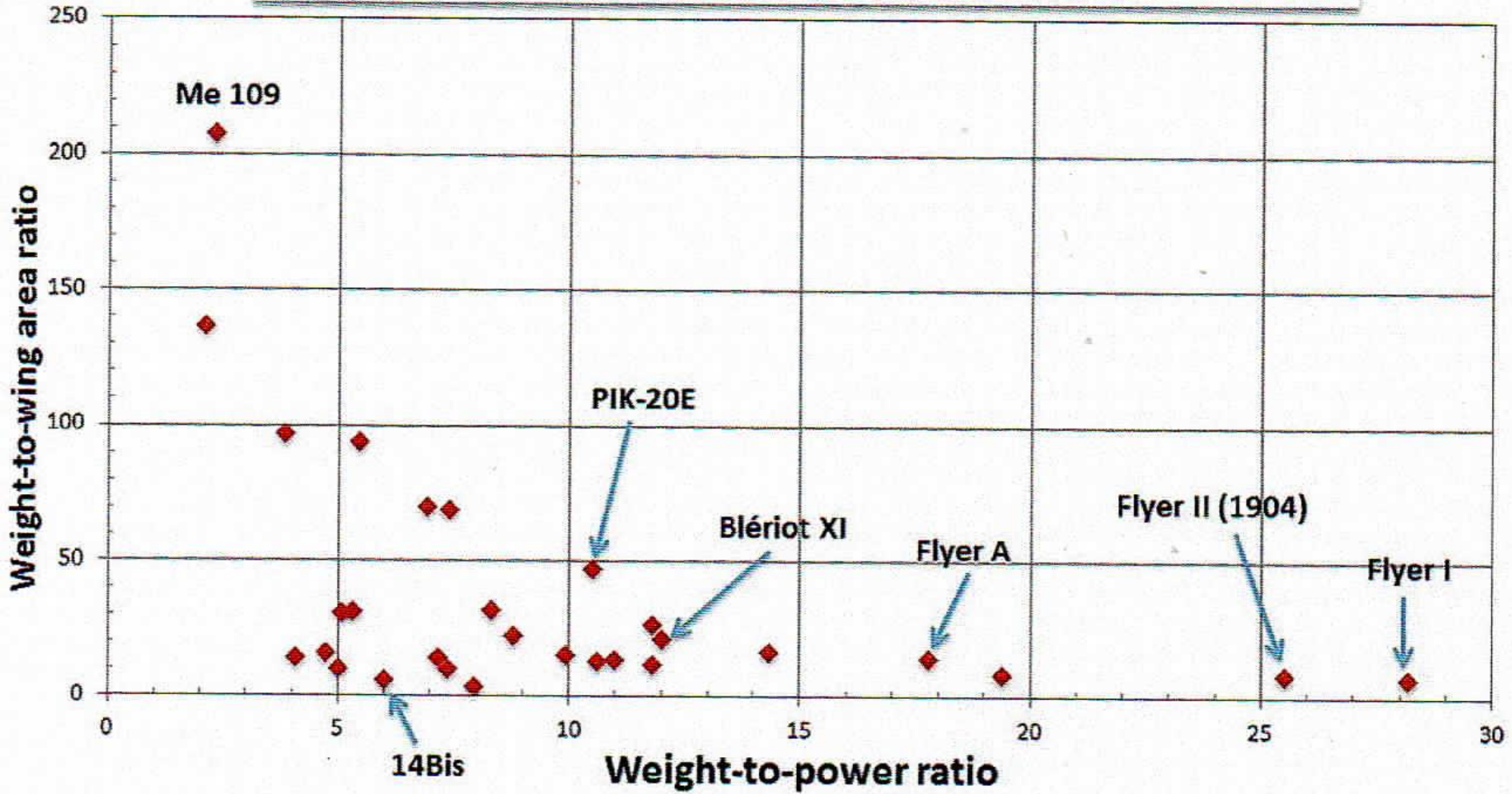
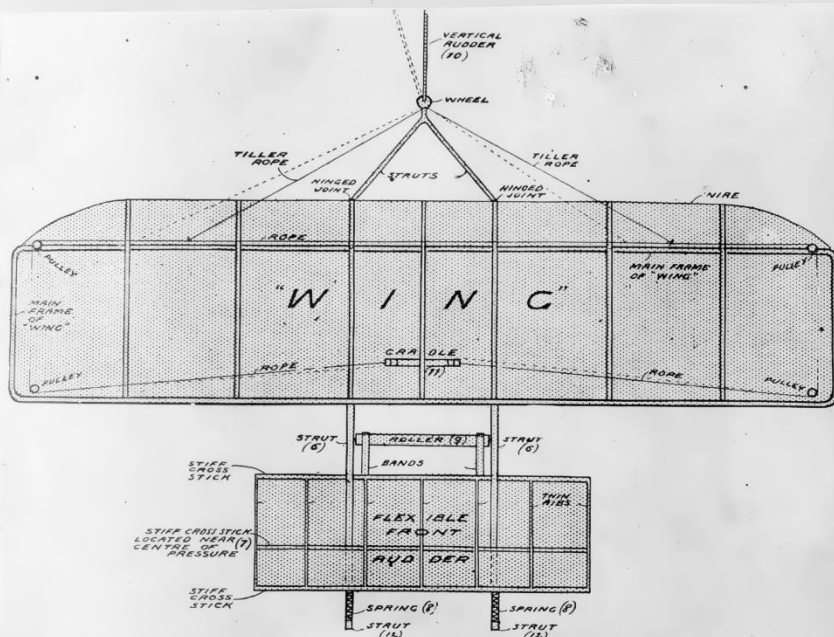


FIGURA 6.20 - A posição do centro de gravidade e a estabilidade longitudinal de um avião.

Piston-powered Single-engined Aircraft





THE TOP PLAN OF THE WRIGHT AEROPLANE.

Drawings by W. B. Robinson from Wright Brothers' specifications in the Patent Office.

CROSS-SECTION OF WRIGHT FLYING MACHINE

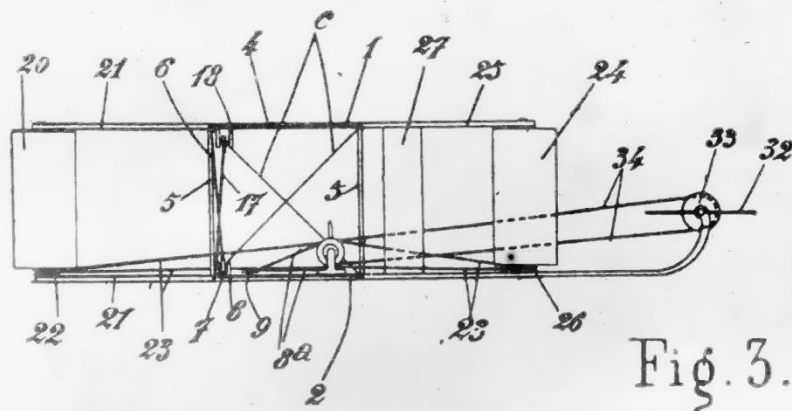


Fig. 3.

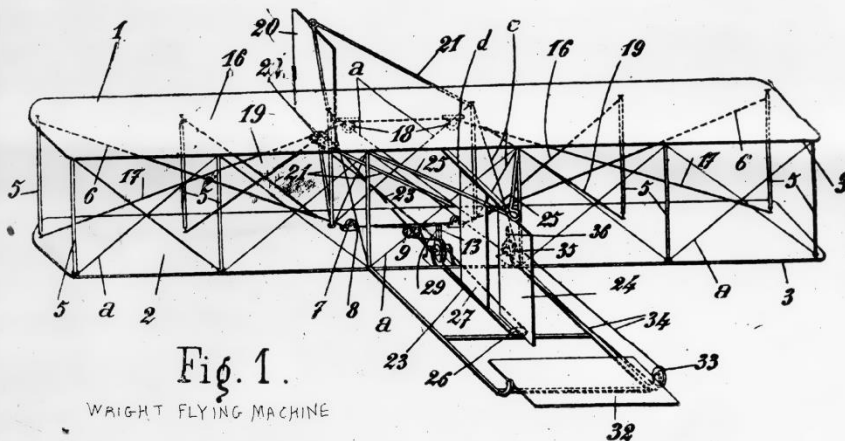
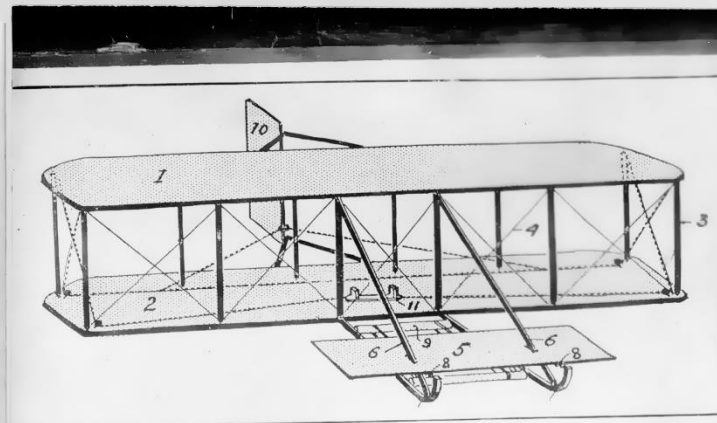


Fig. 1.
WRIGHT FLYING MACHINE










A PERSPECTIVE VIEW OF THE WRIGHT AEROPLANE.

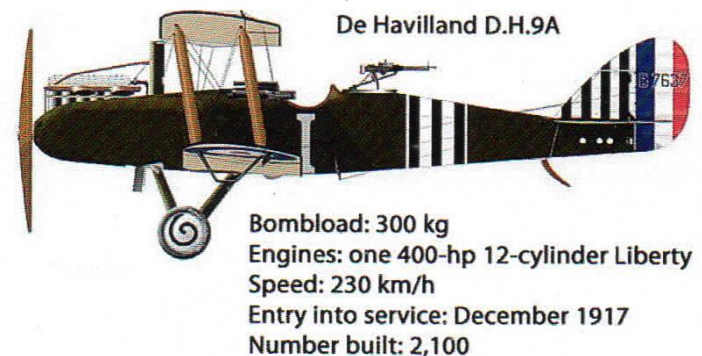
The 1908 Patent effects and war

- The lawsuits damaged the public image of the Wright brothers, who previously had been generally regarded as heroes. Critics said the brothers actions may have retarded the development of aviation, and compared their actions unfavorably to European inventors, who worked more openly.
- In 1908, the Wrights warned Glenn Curtiss not to infringe their patent by profiting from flying or selling aircraft that used ailerons. Curtiss refused to pay license fees to the Wrights and sold an airplane to the Aeronautic Society of New York in 1909 (created by Graham Bell). The Wrights filed a lawsuit, beginning a years-long legal conflict. They also sued foreign aviators who flew at U.S. exhibitions, including the leading French aviator Louis Paulhan. The Curtiss people derisively suggested that if someone jumped in the air and waved his arms, the Wrights would sue.
- The 1908 patent delayed the development of American aircraft in more than ten years. The US entered the first war using French or English planes (SPAD or Neuports).The patent was broken during the WWI due to the battle with Curtiss and others
- The only “contribution” of the patent for the development of aircraft engineering was the fact that other designers developed the aileron (a side effect that promoted a most clever and efficient system for roll/lateral control, used up to day).
- The Wright Aeronautical Corporation, a successor to the original Wright Company, ultimately merged with the Curtiss Aeroplane and Motor Company on July 5, 1929, forming the Curtiss-Wright company, shortly before Curtiss's death.
- After a contract the Smithsonian recognise the “first to fly” to Wrights in 1942!
- There are no NASA site named Wrights but there are NASA-Langley, NASA Glenn etc

Table II - Frontline combat aircraft in the World War I period (Angelucci, 2001).

| Country | Aircraft in service in 1914 | Aircraft in service in 1918 |
|---|-----------------------------|-----------------------------|
|  France | 138 | 4,500 |
|  Great Britain | 113 | 3,300 |
|  Germany | 232 | 2,390 |
|  Italy | 150 | 1,200 |
|  USA | 55 | 740 |
|  Former Soviet Union | 244 | - |
|  Austro-Hungarian Empire | 86 | - |

Fonte Bento Matos

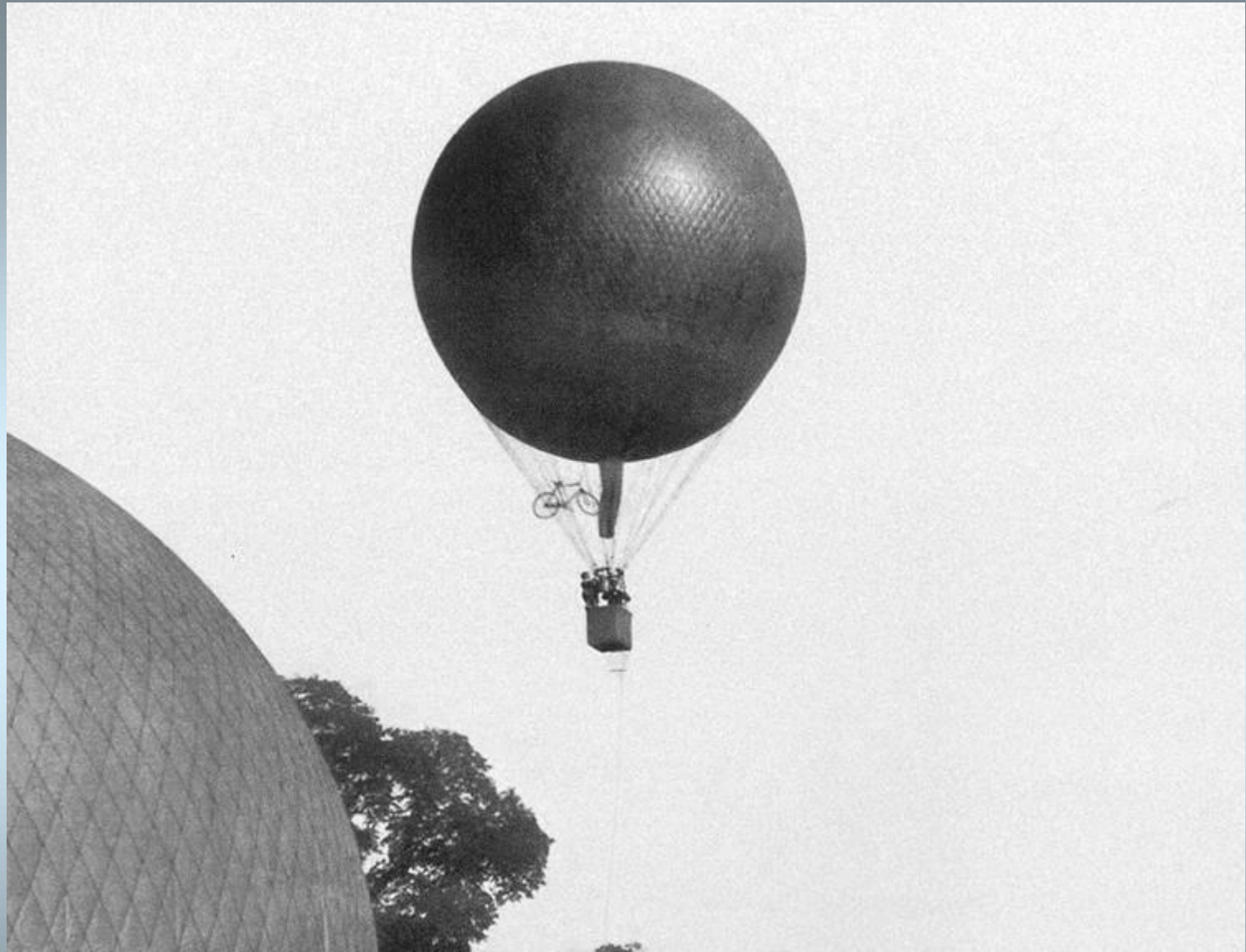


- Alberto Santos Dumont was born in Brazil on July 20th 1873.
- In 1892 he went to France, to advance his studies in engineering.
- On 4 July 1898 his first balloon, named Brasil, took flight in the skies of the French capital. The spherical balloon, filled with Hydrogen, had a diameter of 6 meters.
- He made several flights with Brasil and built two other balloons: the Amérique and the Deux Amériques.





The Hydrogen filled balloon Brasil
(Reproduced from Musa, Mourão and Tilkian, 2003).



The Hydrogen filled balloon Amérique
(Reproduced from Musa, Mourão and Tilkian, 2003).

Santos-Dumont's career up to the No.14-bis



- Between 1898 and 1901 he built five different dirigibles, powered with internal combustion engines, naming them No.1 to No.5.



- In 1898 the Aéro-Club de France was founded and, in 1900, organized the Grand Prix Deutsch de La Meurthe.



- The one hundred thousand Franc prize was to be given to the first dirigible which, starting from Saint-Cloud, went around the Eiffel Tower and back to the starting point in less than 30 minutes.



- On October 19th 1901, Santos-Dumont won the Grand Prix Deutsch de La Meurthe with dirigible No.6 and his popularity spread throughout Europe and the Americas.

Santos-Dumont's career up to the No.14-bis

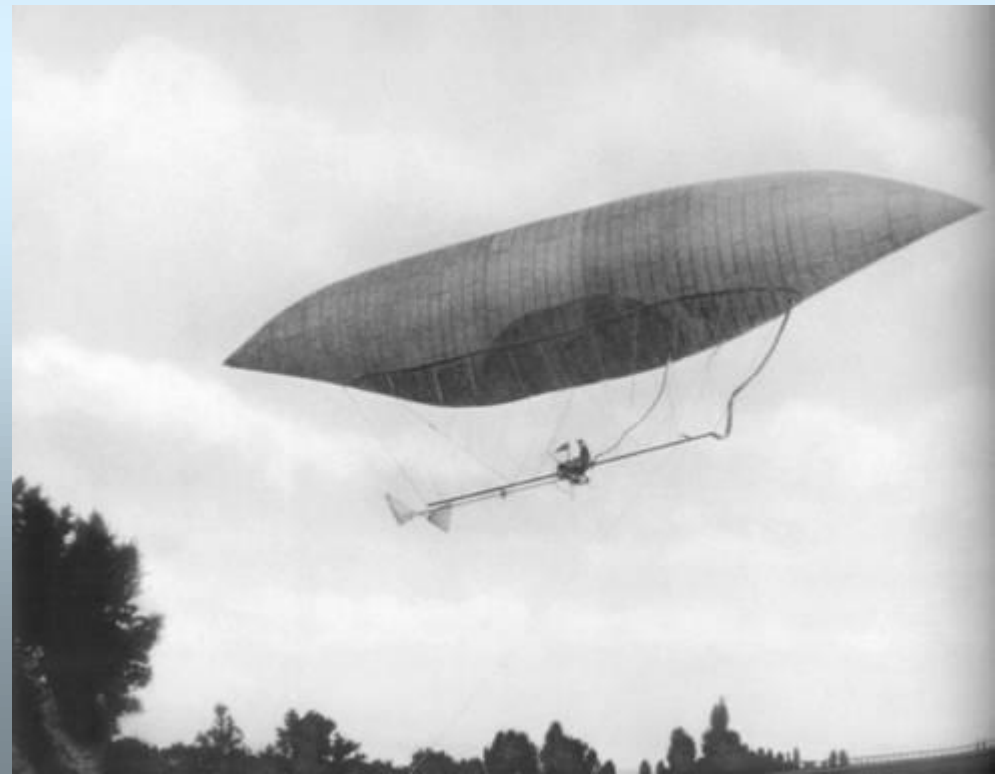
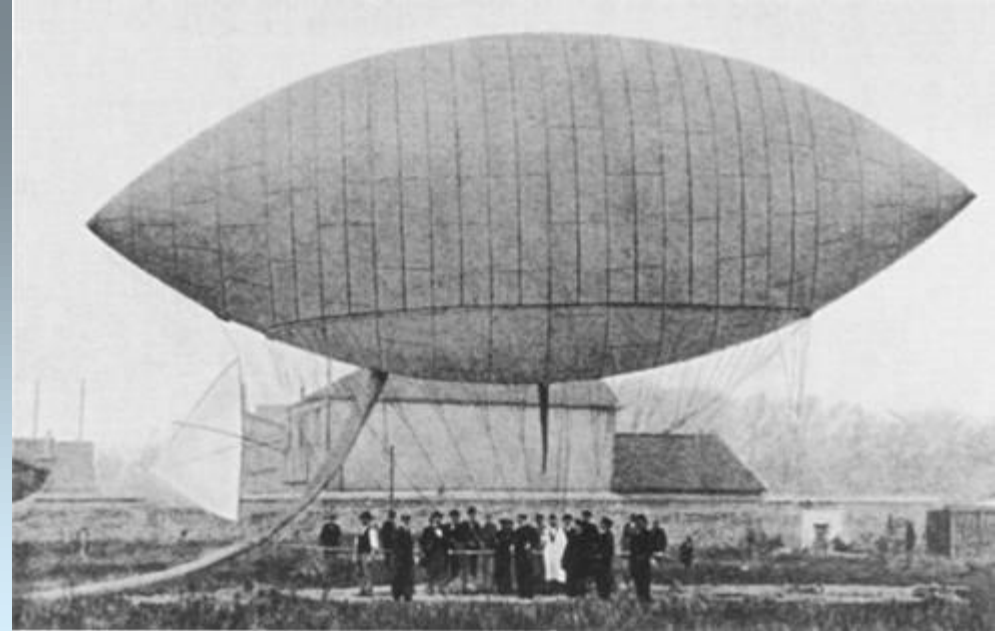
- He continued his experiments with dirigible No.7, which was intended to exceed 80 km/h speed. In June 1904 the aircraft was sent to Saint Louis to participate in a race during the World Fair but it was severely damaged during the trip. Very expensive, it was never rebuilt.



- Dirigible No.9 was built to serve as a personal transport (he skipped No.8 due to superstition). Very small, 12 meters in length, 5 meters in height, it could land on small spaces and became known as the flying chariot.



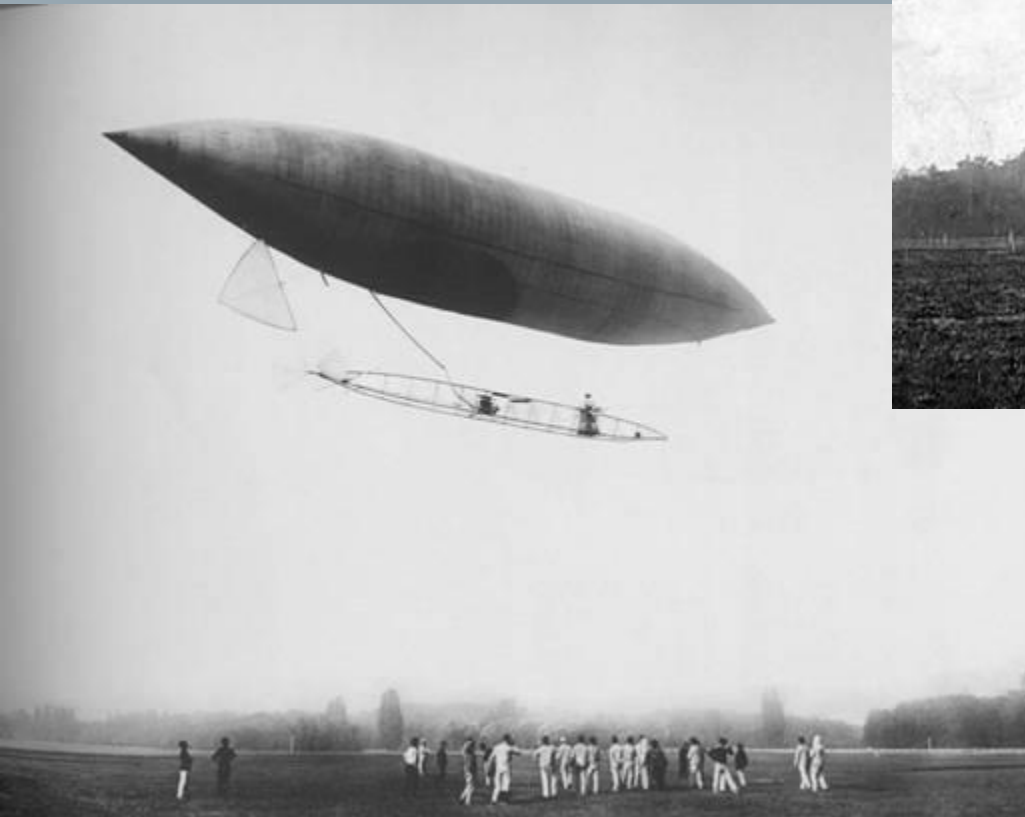
- Dirigible No.10 was designed as a transport for up to 20 passengers but flew only a few times, always arrested by cables, and was abandoned.



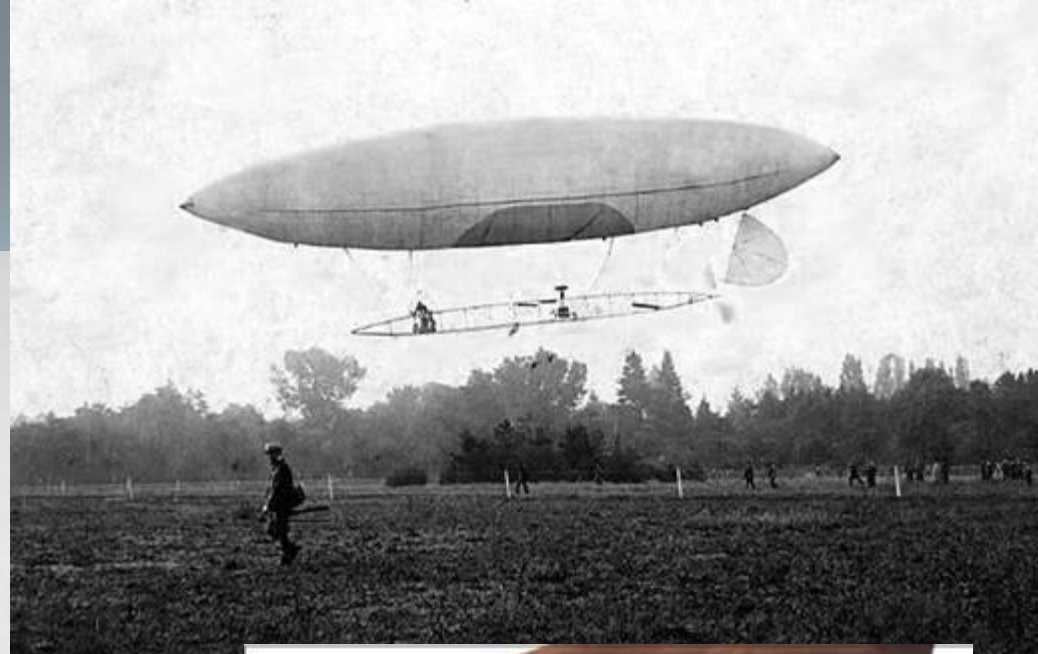
Airships No. 1, 3 and 4
(Reproduced from Musa, Mourão
and Tilkian, 2003).



Airship No.5 crashed against the Trocadero Hotel
(Reproduced from Musa, Mourão and Tilkian, 2003).



Airship No.5



Airship No.6 (Reproduced from Musa, Mourão and Tilkian, 2003)

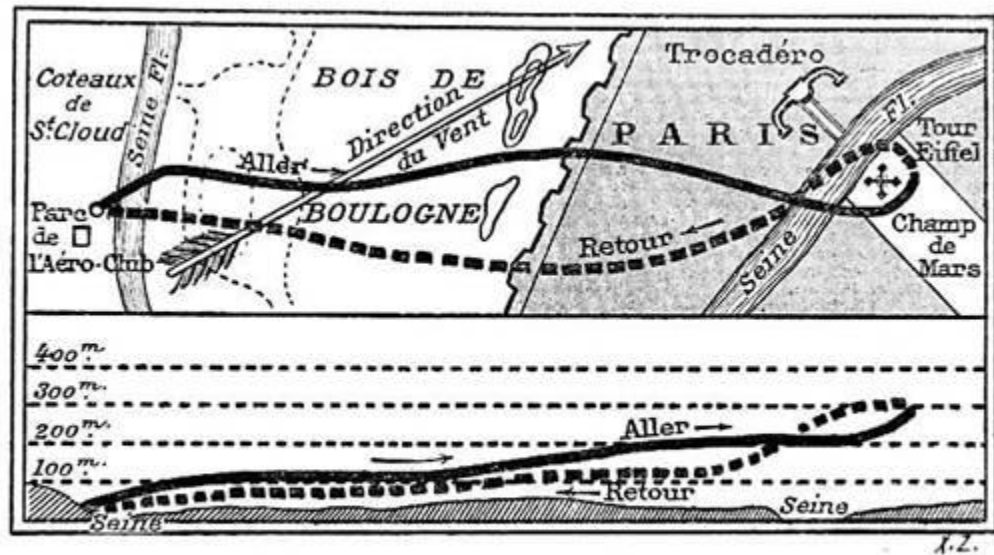
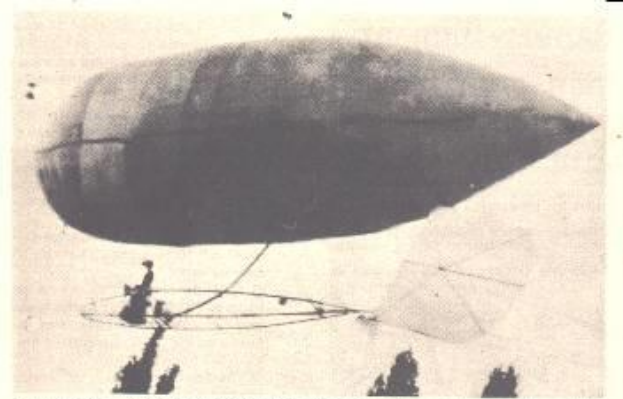
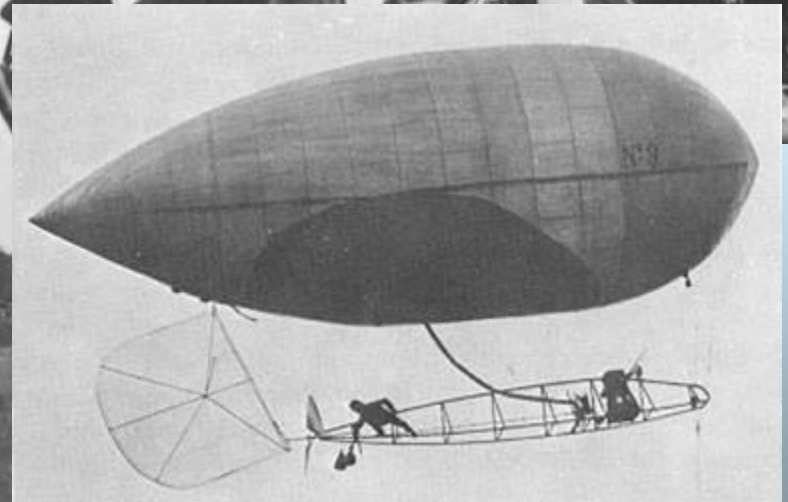
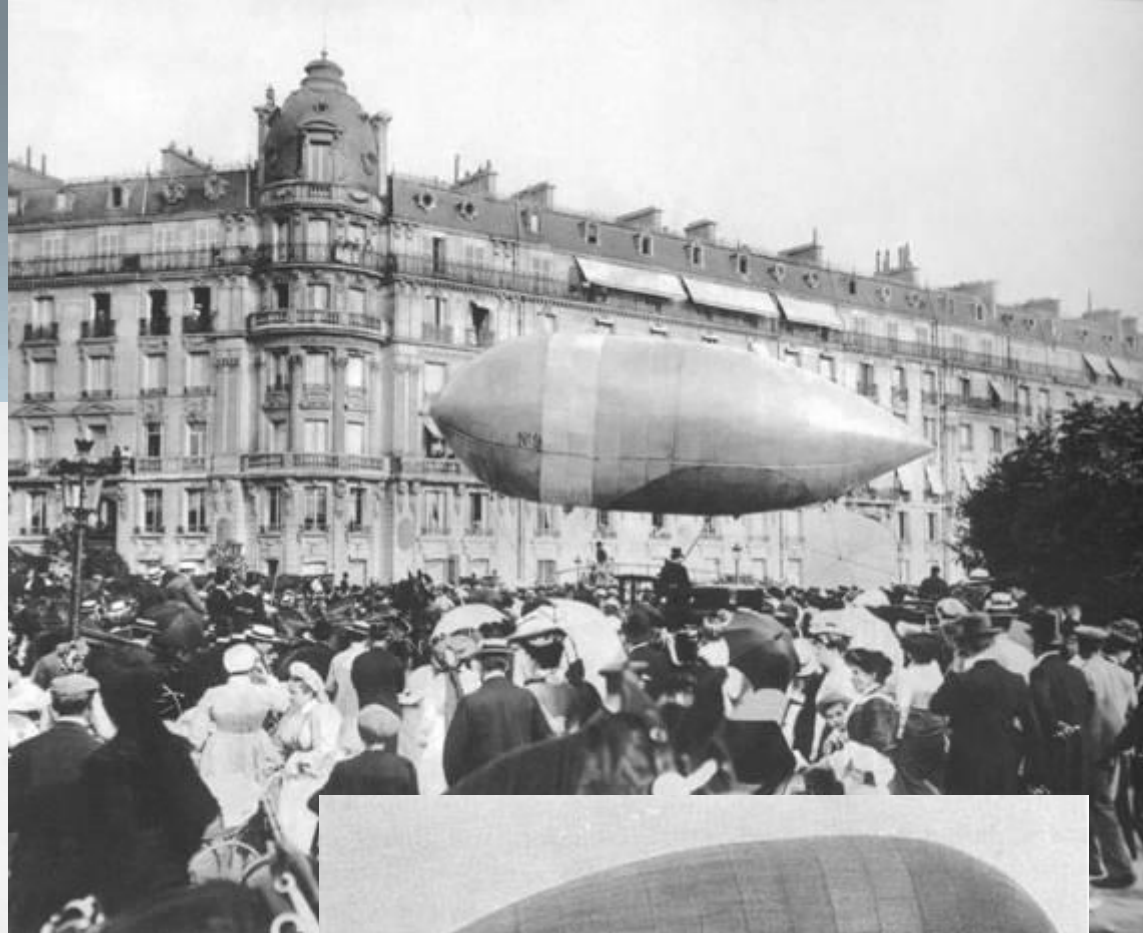


FIG. 32. — CARTE EN PLAN ET EN HAUTEUR DU VOYAGE DE SANTOS-DUMONT
(PRIX DEUTSCH, OCTOBRE 1901).

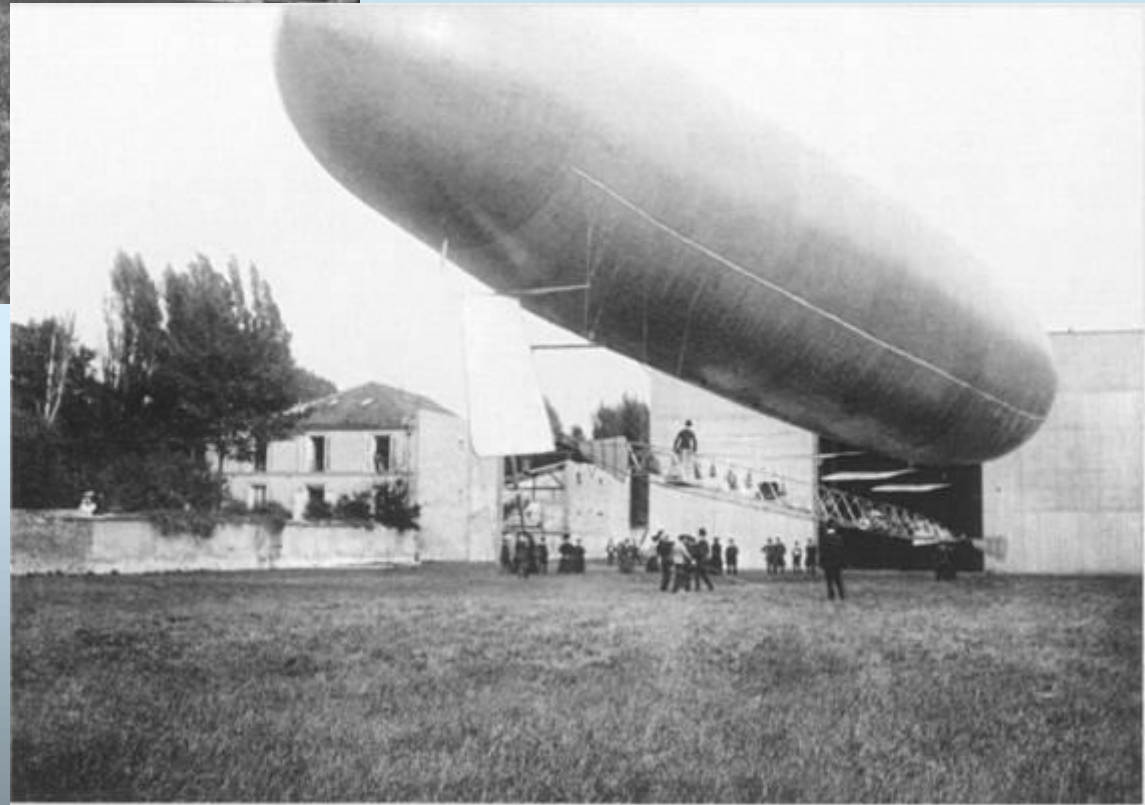
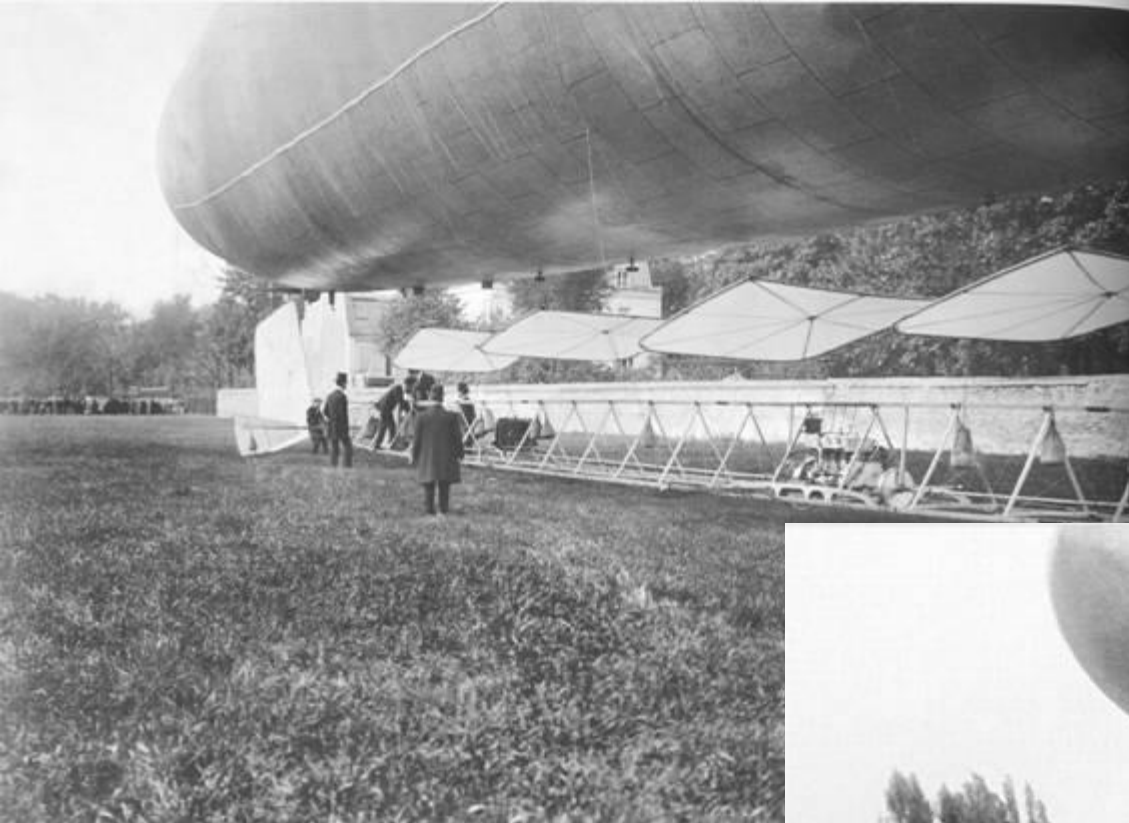
Dirigible No. 6 flying around the Eiffel Tower
(Reproduced from Musa, Mourão and Tilkian, 2003).



29 JUN 1903 — A senhora cubana Aida Decoste realiza sozinha um vôo no balão dirigível n.º 9 de Santos-Dumont.



Airship No. 9 (Reproduced from Musa, Mourão and Tilkian, 2003)

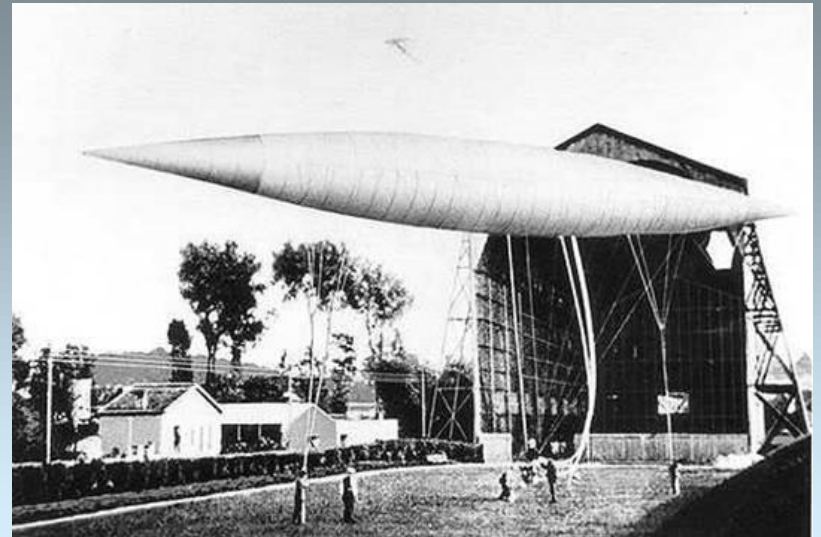


Dirigible No.10 (Reproduced from Musa, Mourão and Tilkian, 2003).



- In the beginning of 1905 he designed and built dirigible No.14 as a fast, highly maneuverable aircraft.
- To motivate further advances in aeronautics the Aéro-Club de France instituted, in the end of 1905, a 1,500 Franc prize for the first aeronaut to realize a 100 meter long flight on an airplane taking-off by its own means from level ground (a maximum 10% slope). At the same time Ernest Archdeacon, club president, offered 3,000 Franc for a 25 meter long flight.
- Santos-Dumont and his assistants then started to work on a biplane aircraft based on Hargraves' box kites.

No. 14

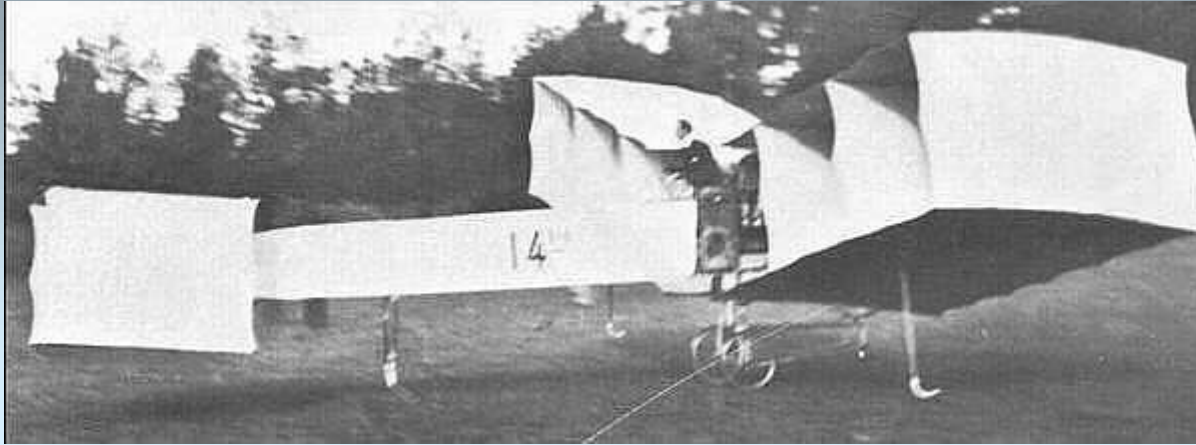


No. 14 for
speed record

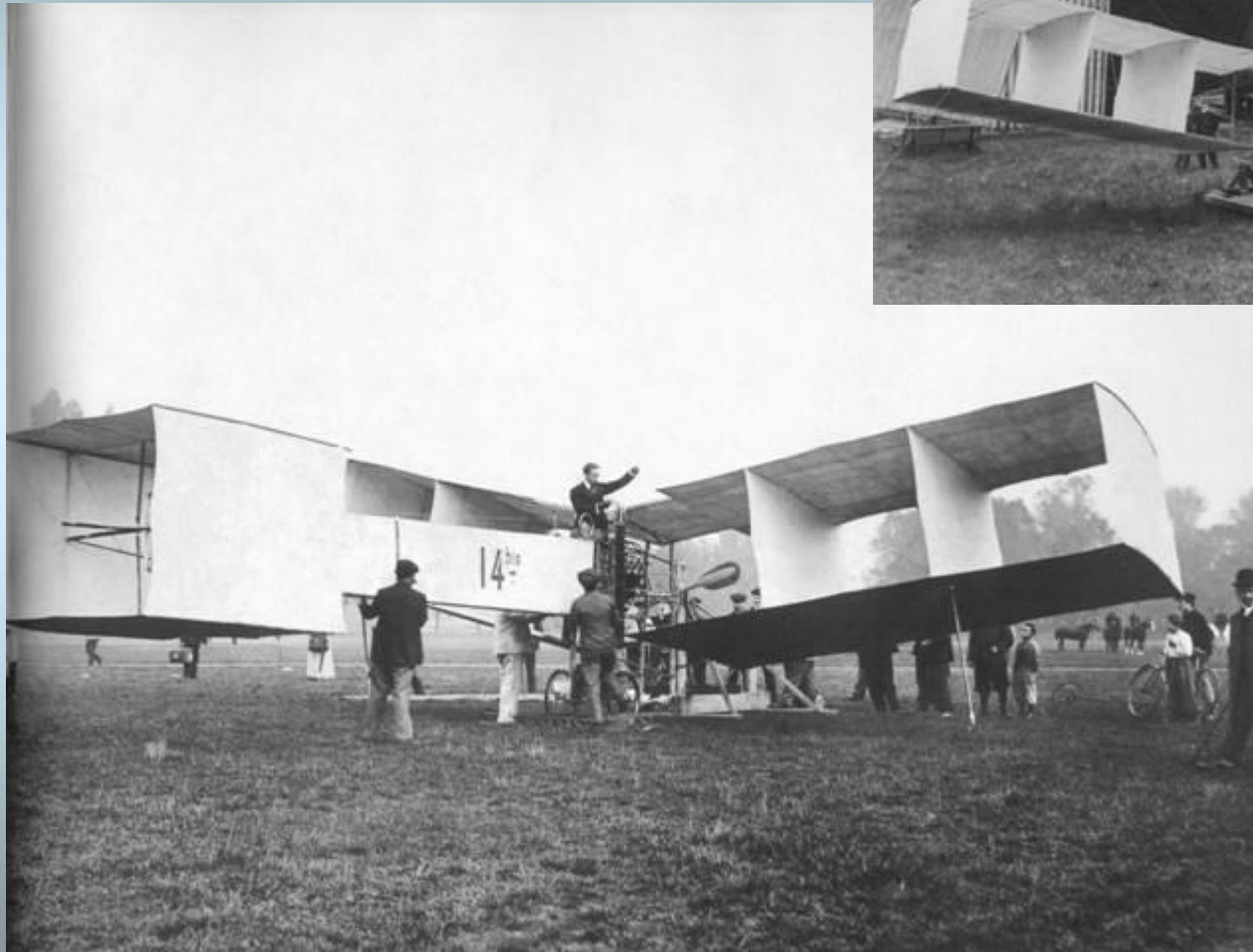


- Santos-Dumont was also very interested in heavier than air aircraft and, by the end of 1904, he started to explore the possibility of powered flight.
- He designed a monoplane, No.11, for which he did not find a suitable engine.
- He also built the prototype of an helicopter, No.12, with two large propellers powered by a 24 HP, eight cylinder engine. He never tried to make it fly.
- His next balloon, No.13, combined hot air and Hydrogen for aerostatic lift. It was destroyed during a storm before it could be tested.

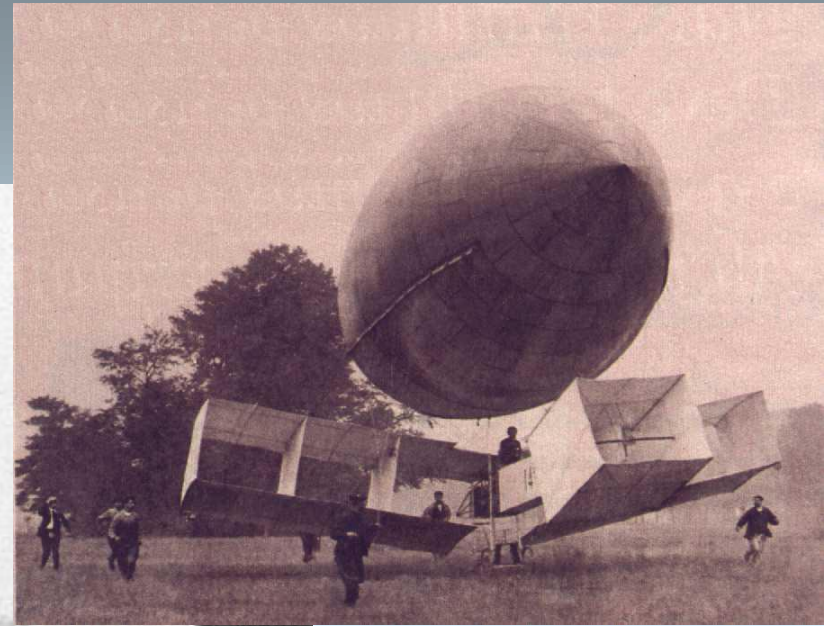
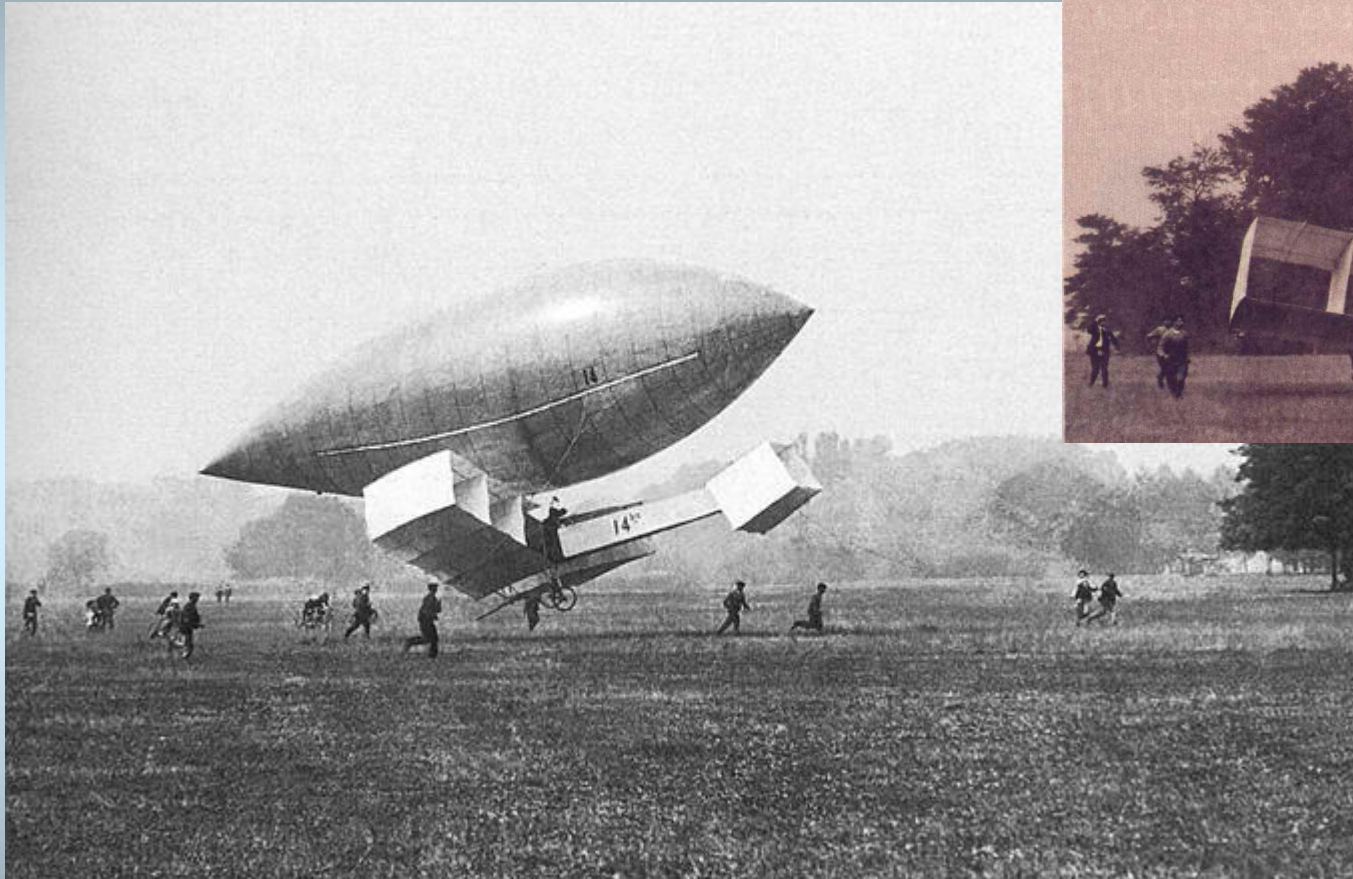




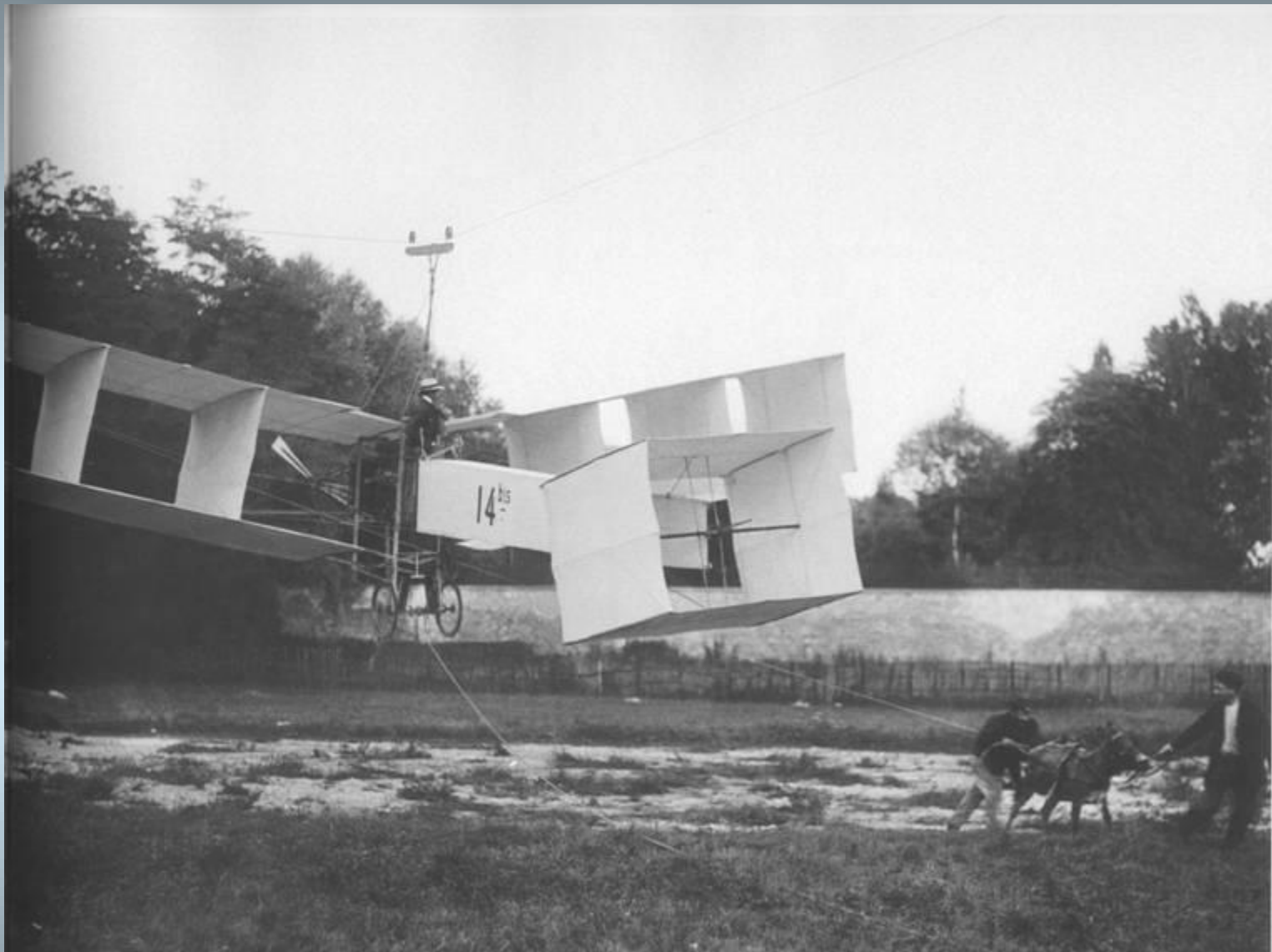
The aircraft, made of bamboo poles and silk covering, with aluminum fixtures, was powered by a single 24 HP Antoinette engine. The engine, placed at the airplane rear end, drove a two blade, paddle type propeller in a pusher configuration.



The 14-Bis (Reproduced from Musa, Mourão and Tilkian, 2003).



The 14-Bis attached to dirigible No.14
(Reproduced from Musa, Mourão and Tilkian, 2003).



The 14-Bis suspended by cables for stability tests
(Reproduced from Musa, Mourão and Tilkian, 2003).



The 14-Bis wing being transported by a car
(Reproduced from Musa, Mourão and Tilkian, 2003).



- After several test runs Santos-Dumont replaced the engine with a 50 HP, V-8 Antoinette. He also elevated the fuel reservoir, removed the rear wheel, coated the wing, reduced the propeller axle length and the wing incidence angle.
- On October 23rd 1906 Santos-Dumont flew 60 meters with the 14-Bis to win the Archdeacon prize.
- For the next flight he installed two control surfaces inside the outboard Hargrave's cells.(the first successful use of ailerons)
- On November 12th 1906 he won the Aéro-Club de France prize flying 220 meters in 22 seconds setting the first airplane record.





- Santos Dumont then designed and built a new biplane the No. 15. It crashed during the attempts to take-off and was abandoned.



- His next project was an hybrid airplane-dirigible, No.16, with a small lifting surface and canard. That aircraft also failed to take-off.



- He tried, without success, to improve the No.15 with the No. 17.



- He also developed a racing boat, No.18, with hydrofoils and a three bladed propeller.



- In 1907 Santos-Dumont had the idea of building a very light airplane. He designed and built No.19, the Demoiselle, an aircraft with a 6 meter wing span and a 24 HP engine of his own design.
- By this time, in 1907, other Frenchmen were also flying:
 - Voisin - 60m in March
 - Blériot - 100m in April
 - Farman - 771m on October 26
 - Esnault-Pelterie - 600m in November
 - Voisin-Farman - 1+ km on November 9
- The Demoiselle was very successful in flying, became very popular and its development continued as No.20, No.21 and No.22 (his last airplane).



- In 1909 Santos-Dumont received the first pilot license from the Aéro-Club de France along with Henri Farman, Louis Blériot, Wilbur Wright, Orville Wright, Léon Delagrange, Robert Esnault-Pelterie and Captain Ferber. He made his last flight as a pilot in January 1910.



Santos Dumont within
Voisin and Farman

GEOMETRIC CHARACTERISTICS OF THE 14-BIS

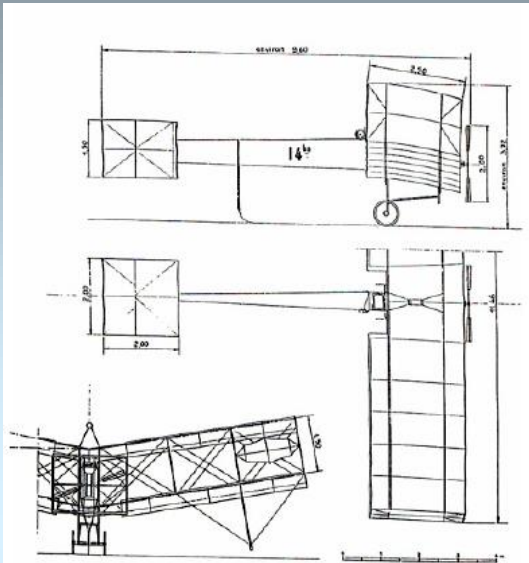


FIG 13 14-Bis plans reproduced from Pégase magazine (Lissarrague, 1983).

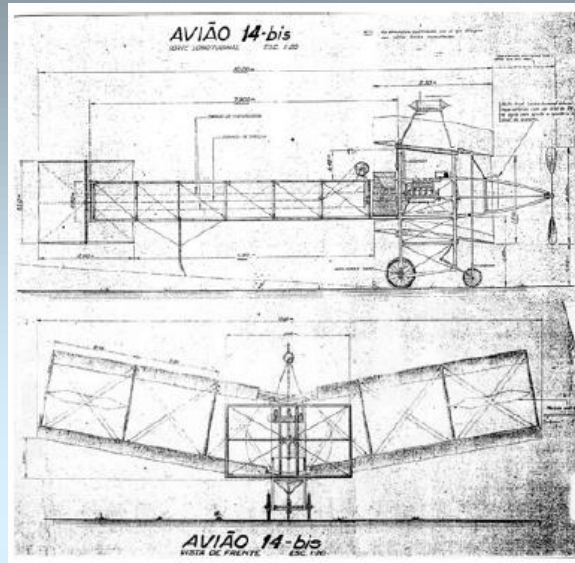


FIG 12 14-Bis plans obtained from the Aerospace Museum of Rio de Janeiro.

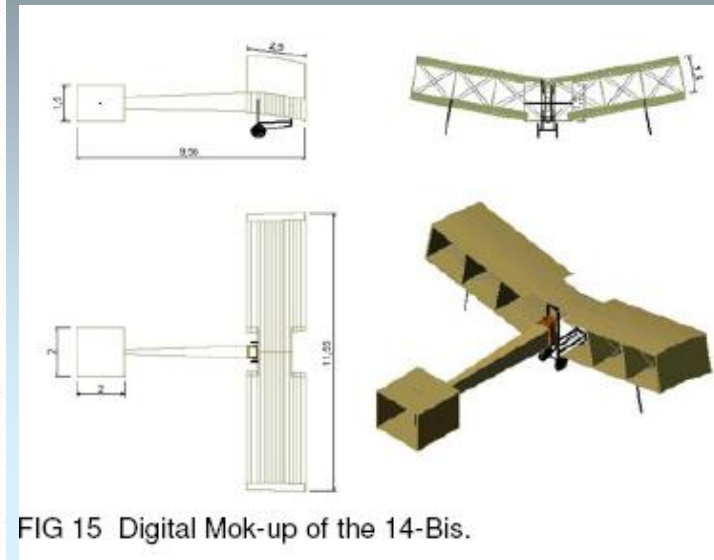


FIG 15 Digital Mok-up of the 14-Bis.

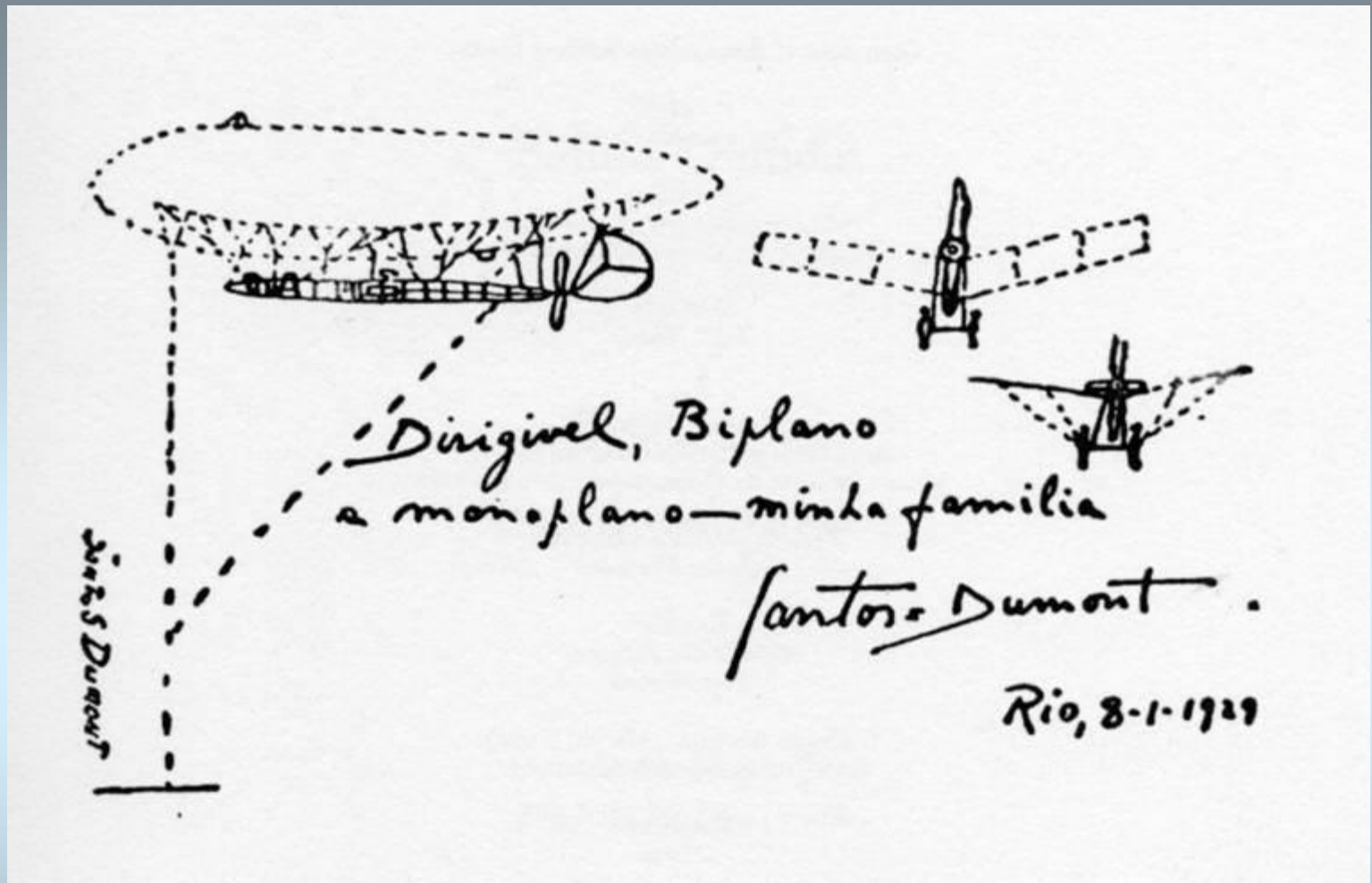




| | | |
|---|---------------|-------------|
| Variation of lift coefficient with angle of attack | $C_{L\alpha}$ | 3.6 1/rad |
| Variation of pitching moment coefficient with angle of attack | $C_{m\alpha}$ | -0.03 1/rad |
| Variation of lift coefficient with pitch rate | C_{Lq} | 4.4 s/rad |
| Variation of pitching moment coefficient with pitch rate | C_{mq} | -5.4 s/rad |
| Variation of side force coefficient with sideslip angle | $C_{Y\beta}$ | -0.12 1/rad |
| Variation of yaw moment coefficient with yaw rate | C_{nr} | -1.5 s/rad |
| Variation of rolling moment coefficient with roll rate | C_{lp} | -0.41 s/rad |







An autograph given by Santos Dumont:
“dirigible, biplane and monoplane – my family”.

The Demoiselle heritage

- The Demoiselle influenced many others aircrafts



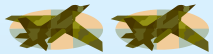
- Grade in Germany



- Fokker



- Belanca Aeronca



- Was used by many countries



- Santos-Dumont's heritage for Brazil



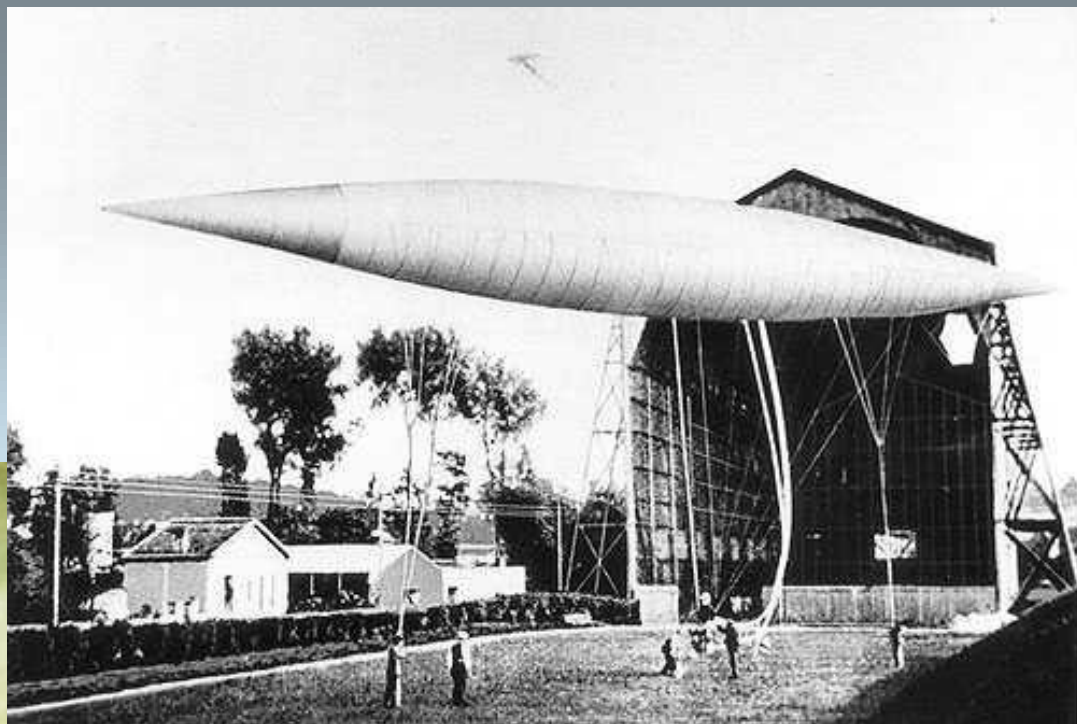
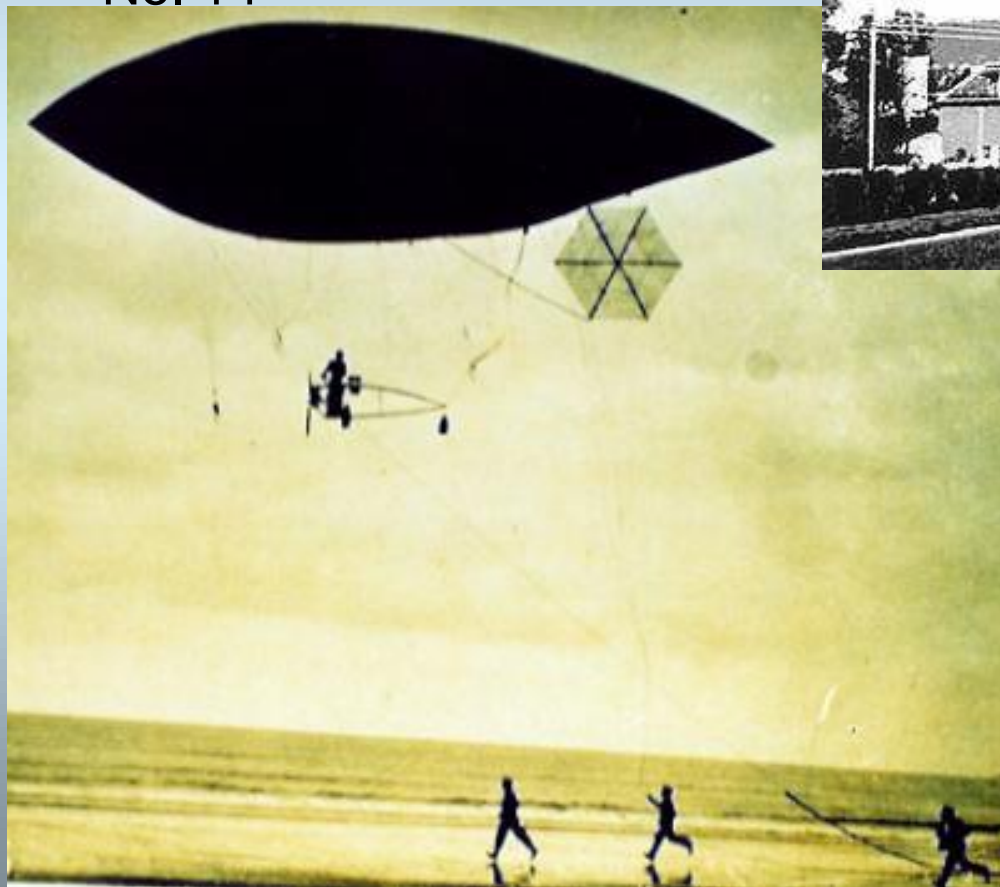
The Demoiselle should be considered
as the precursor of the modern airplane

First airplane that fully satisfies the criteria for
physical and conceptual precursors:
performs the same basic function
(unassisted take-off, maneuvering and landing)
is a link in an unbroken chain that leads to the
modern airplane through incremental
development

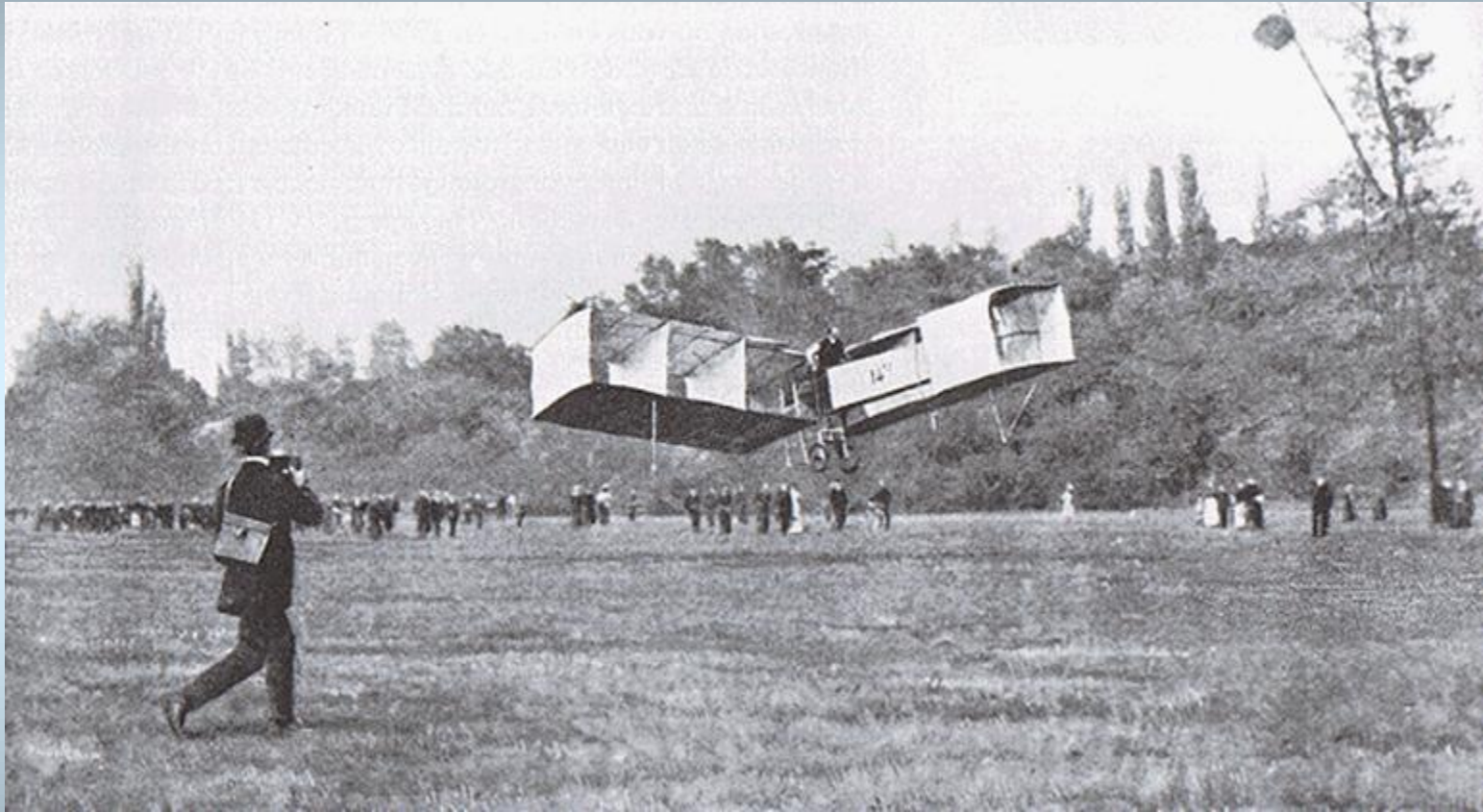
Thank you!



No. 14



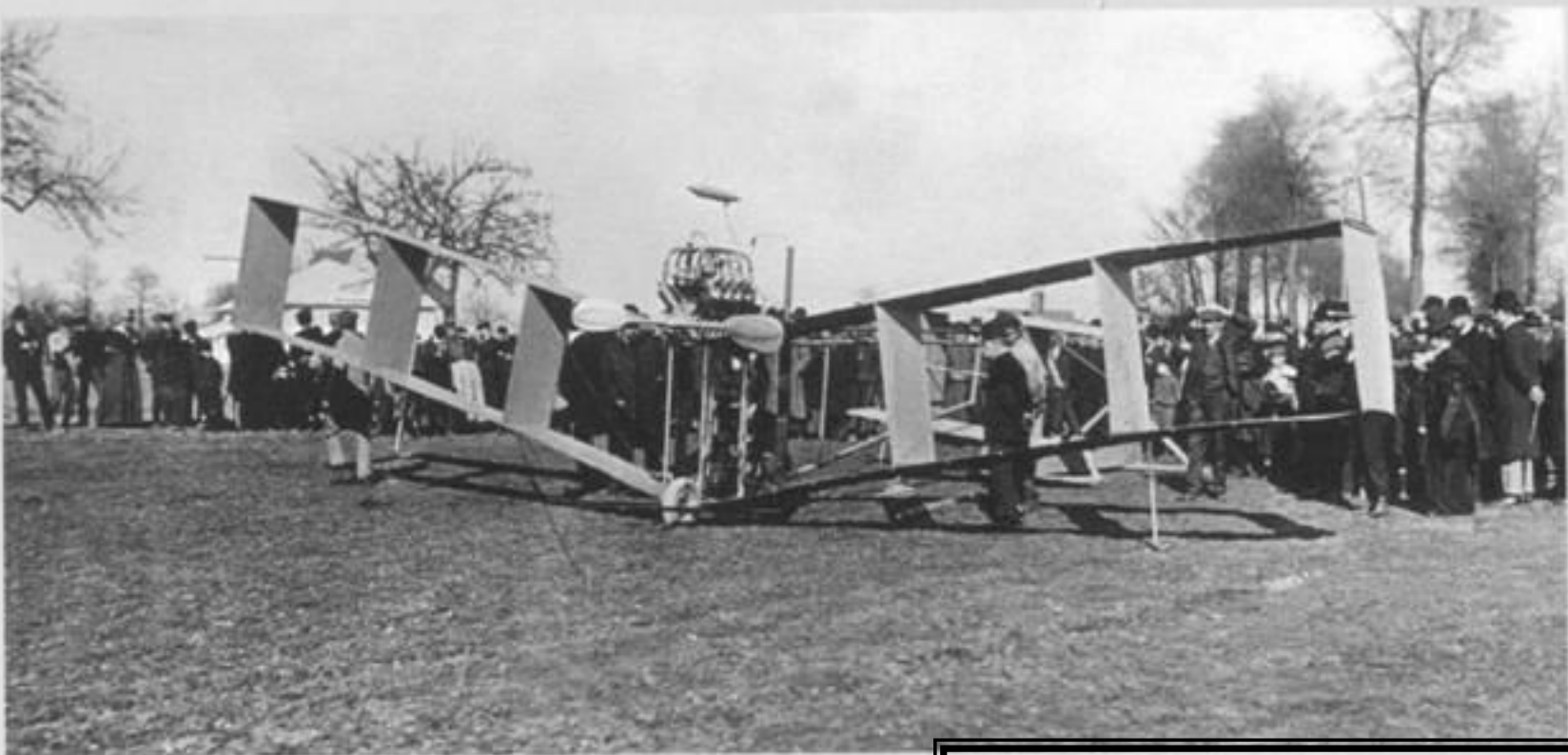
No. 14 for
speed record



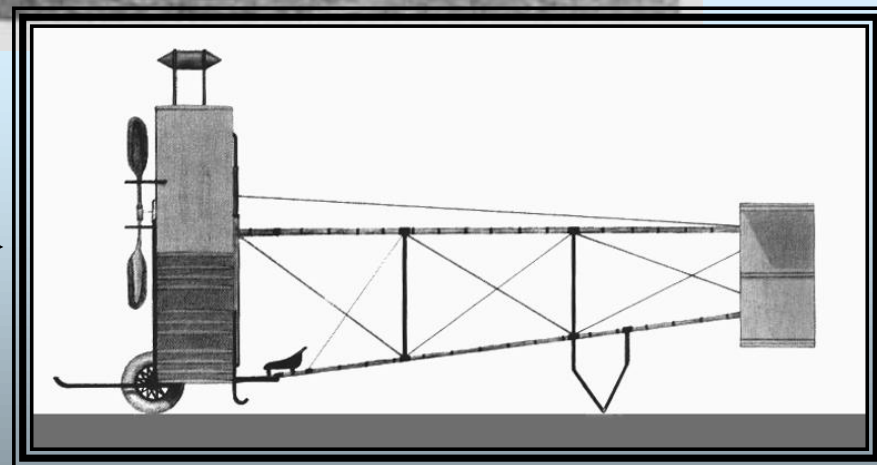
Photograph of Santos Dumont's 14-Bis flight on October 23rd 1906
(Reproduced from Musa, Mourão and Tilkian, 2003).



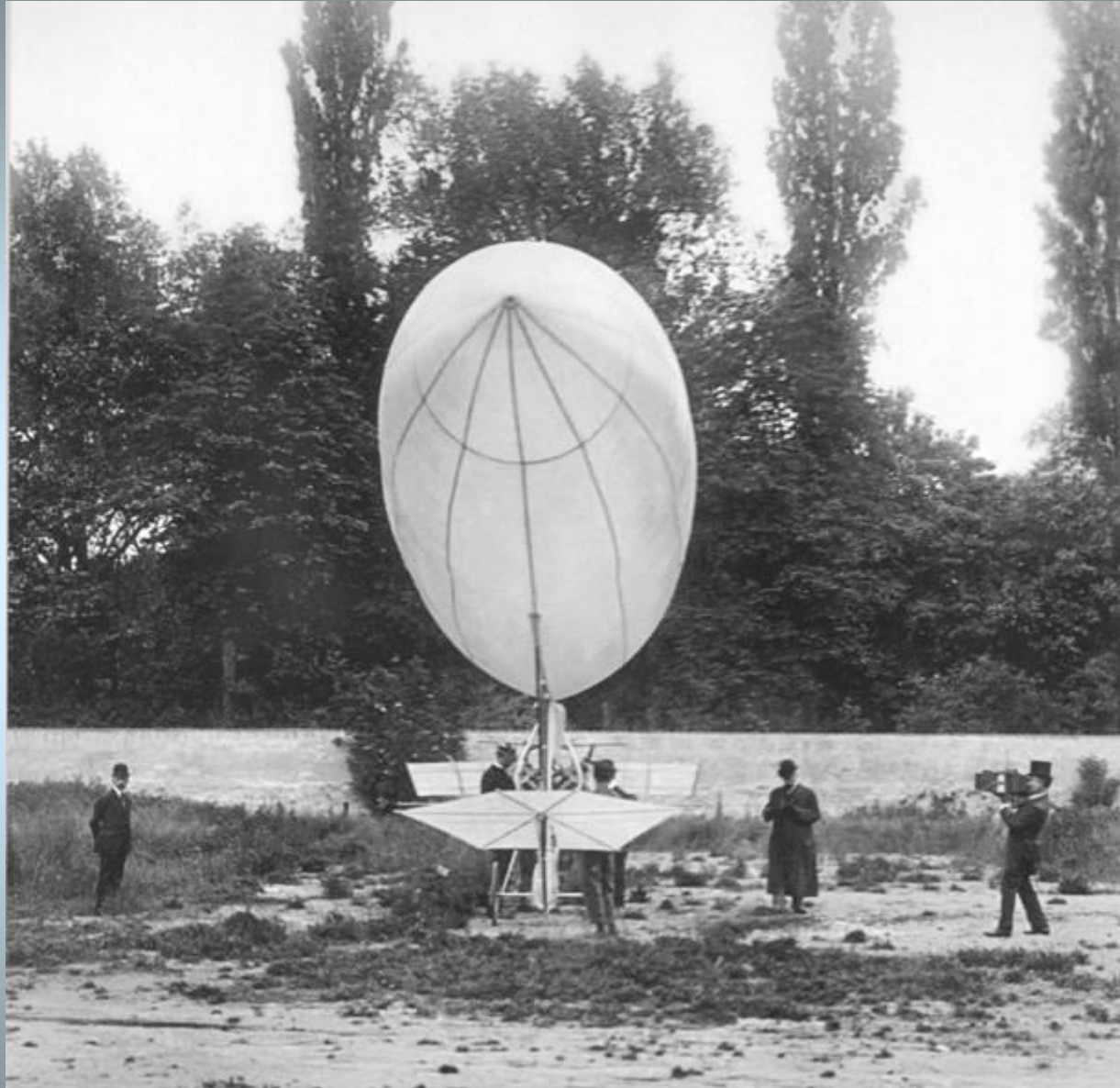




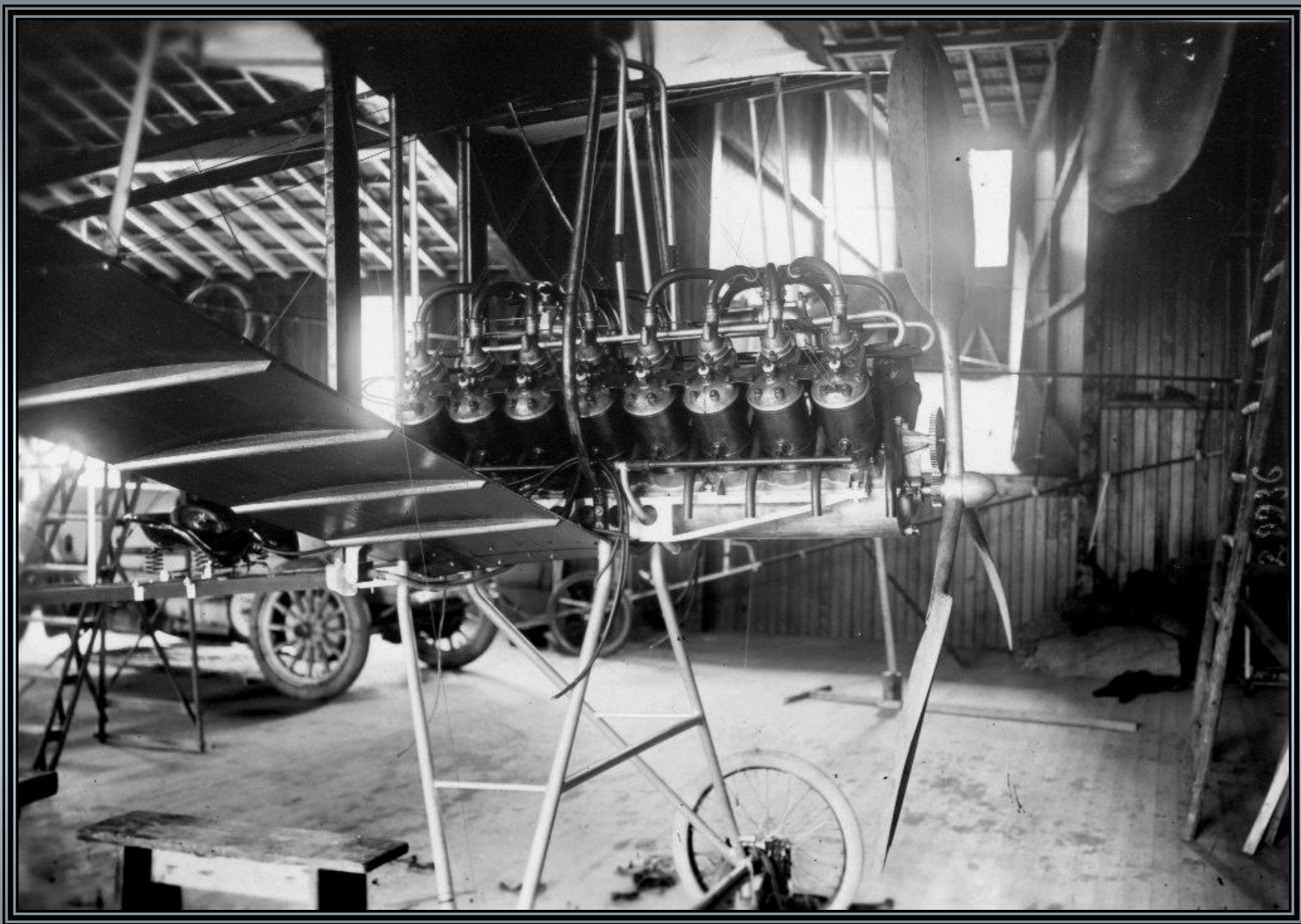
N°15 could
not rotate !

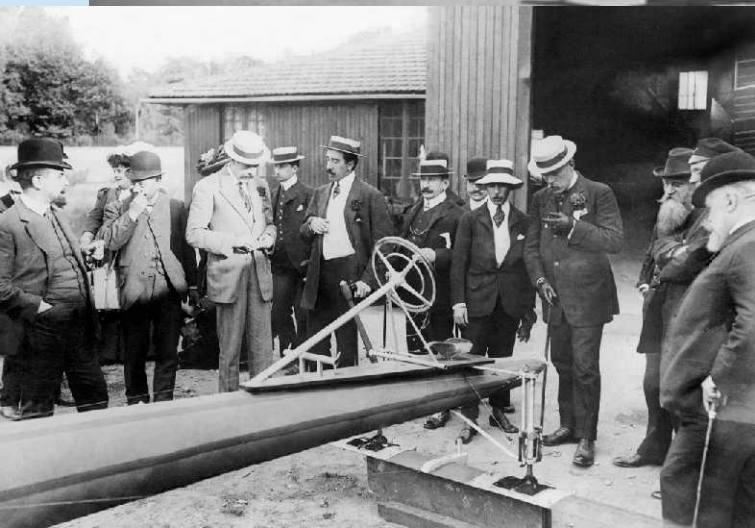


Airplane No.15 (Reproduced from Musa, Mourão and Tilkian, 2003).

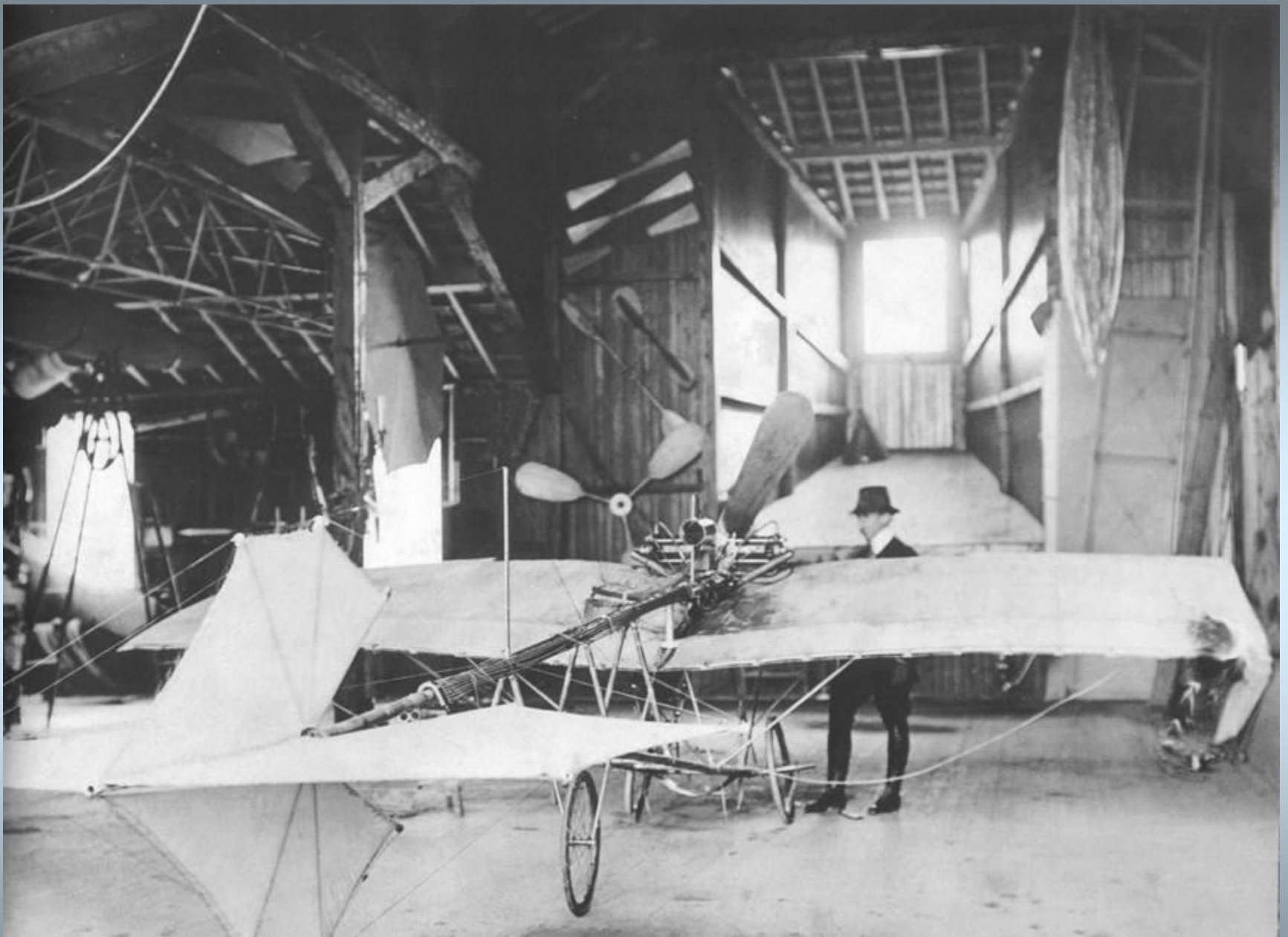


Hybrid aircraft No.16 (Reproduced from Musa, Mourão and Tilkian, 2003).





Racing boat No.18



Airplane No.19 Demoiselle
(Reproduced from Musa, Mourão and Tilkian, 2003).

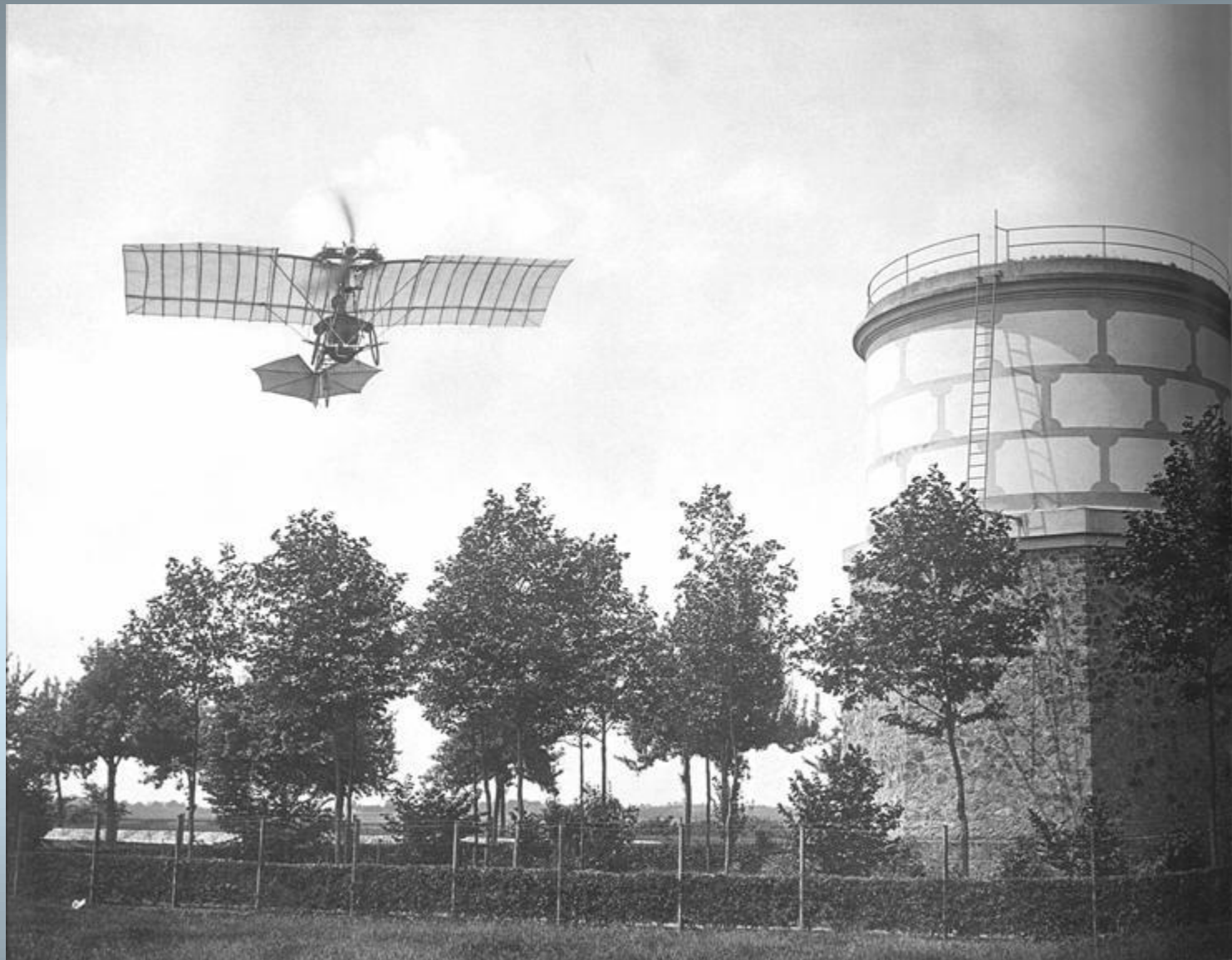
Aeroclub
referees



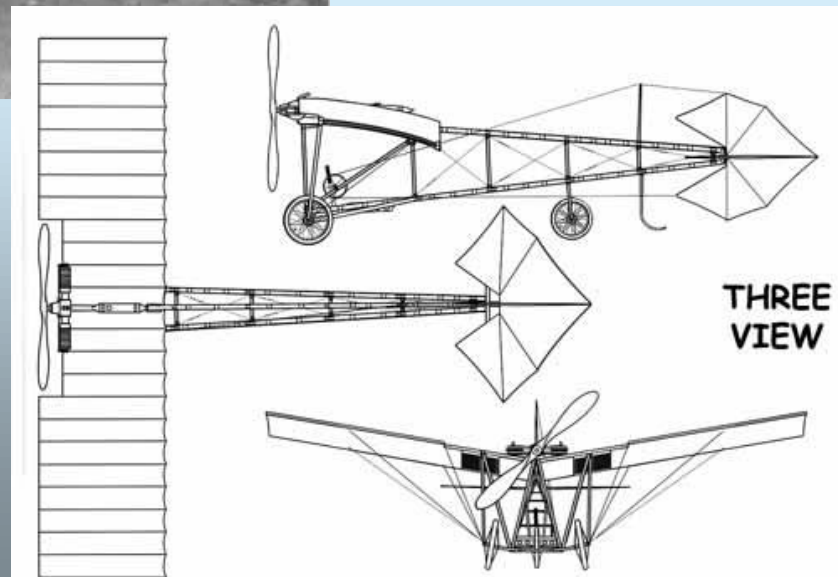
Airplane No.19 Demoiselle
(Reproduced from Musa, Mourão and Tilkian, 2003).

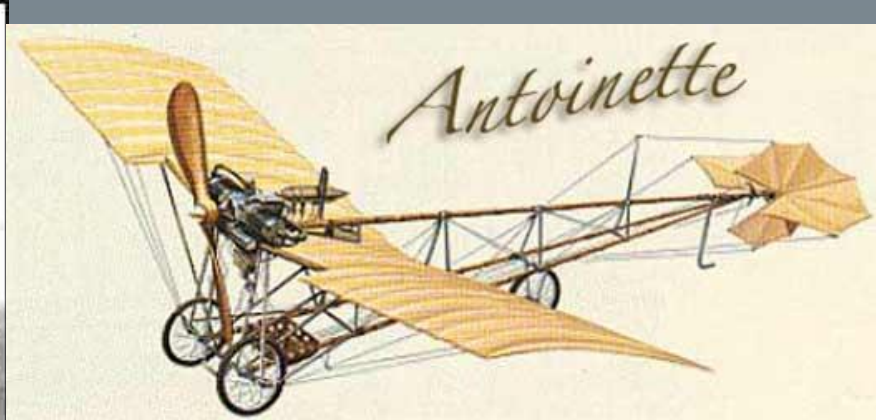


Transporting the Demoiselle
(Reproduced from Musa, Mourão and Tilkian, 2003).



The Demoiselle in flight
(Reproduced from Musa, Mourão and Tilkian, 2003).







Grade Monoplane ~ 1910



www.borkheide.de/grade.htm

<http://aerobscur.free.fr>

Hans Grade
(Germany first
practical aircraft)





The first Fokker airplane:
the Spin





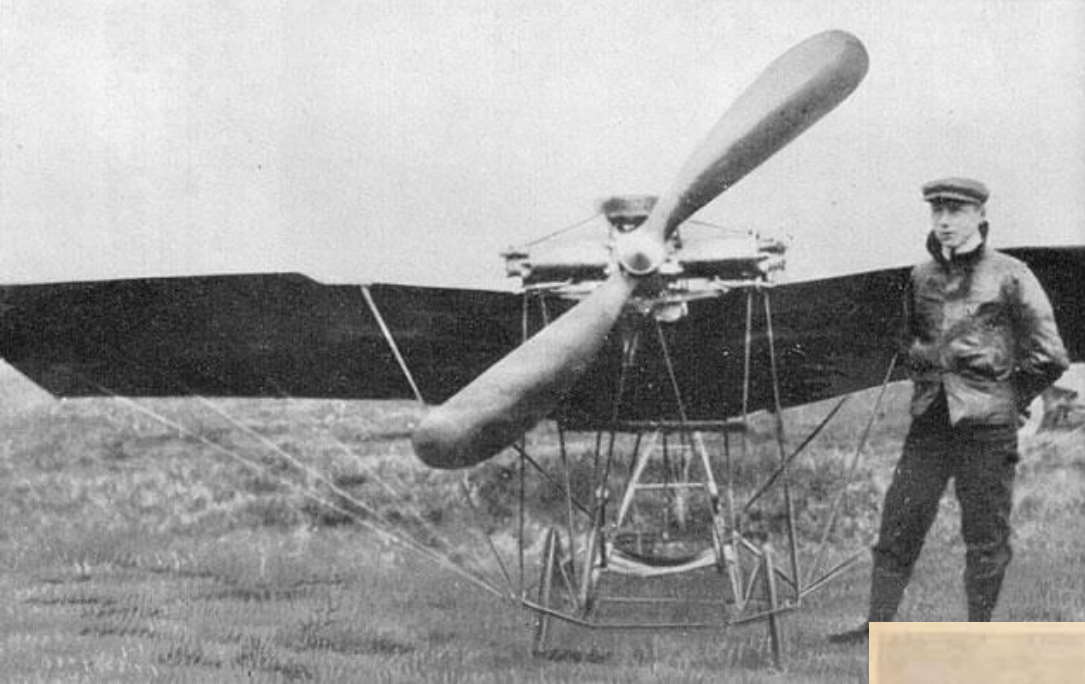
Aeronca C3



Belanca

Demoiselle in Tampareela Finland 1910-1913





Austrian air force training



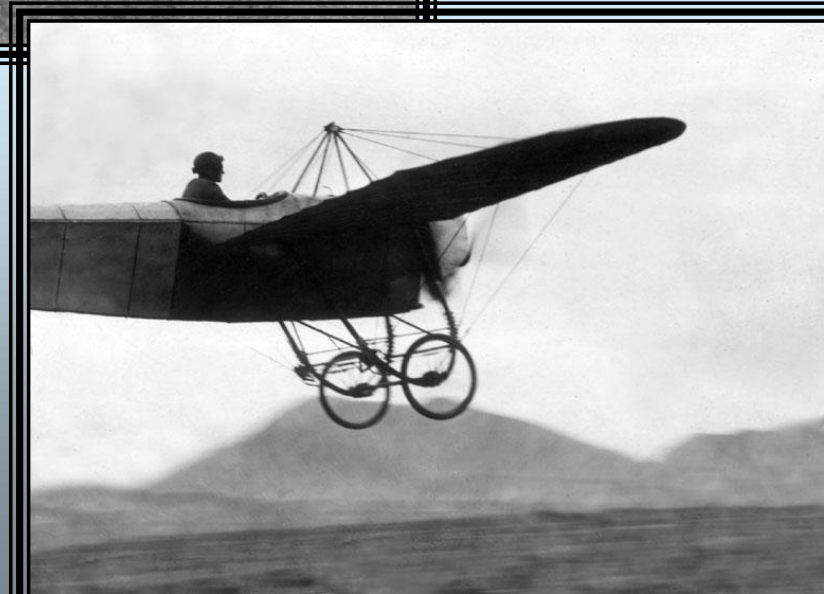
Kuvanveistäjä Aarnon lentokone. Ohjaamossa joht. Yrjö Pyhälä, eräs Ain avustajista.
Vieressä kirjoittajamme, maj. R. Ahonius.

Brazil was designing and building airplanes even before the First World War



1910 - the *São Paulo*

1914 - the *Alvear*



EMBRAER

from turboprops . . .



EMB 110



EMB 121



EMB 120

EMBRAER – Regional Aircraft Products



EMBRAER 170

70 to 80 Seats - 2,000 nm Range
Certification – 1st Q/2004



EMBRAER 175

78 to 88 Seats - 1,900 nm Range
Certification – 4th Q/2004



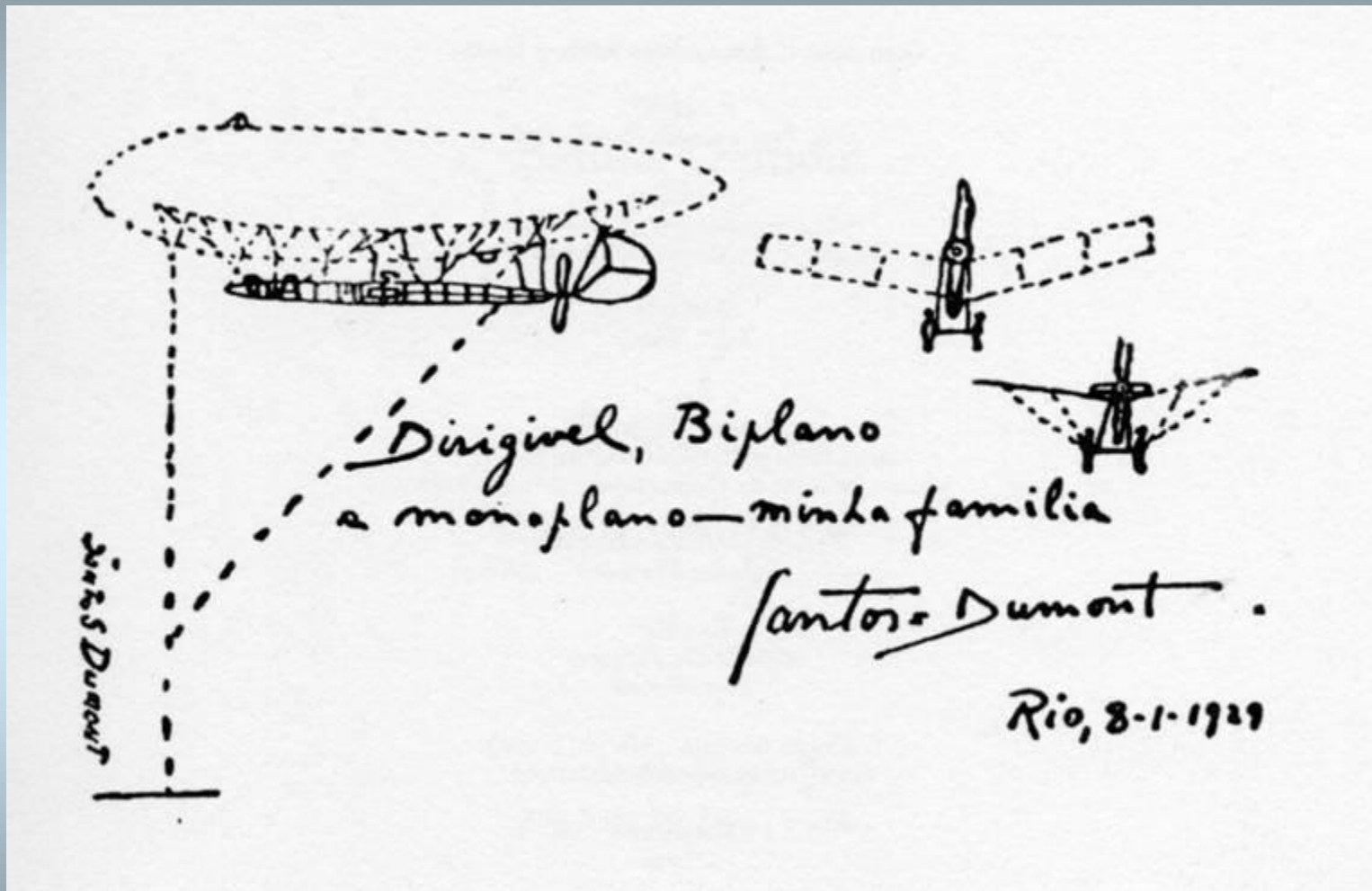
EMBRAER 190

98 to 114 Seats - 2,300 nm Range
Certification – 3rd Q/2005



EMBRAER 195

108 to 122 Seats – 2,100 nm Range
Certification – 2nd Q/2006



An autograph given by Santos Dumont:
“dirigible, biplane and monoplane – my family”.

EMBRAER – Corporate Jets

PHENOM™ 100
BY EMBRAER



THE VERY LIGHT,
VERY CREDIBLE JET.

The very light jet has evolved.
What began as a radical notion has
become a solid, elegant answer to
executive travel demands.

PHENOM™ 300
BY EMBRAER



A PROMISE KEPT.

The Phenom™ 300 keeps the old
promises of private aviation - as it
sets new expectations.

EMBRAER
Executive Jets

LEGACY™
BY EMBRAER

THE EVOLUTION OF BUSINESS TRAVEL.



LEGACY 600
More

Lineage™ 1000
BY EMBRAER



THE NEW MEASURE
OF LUXURY.