



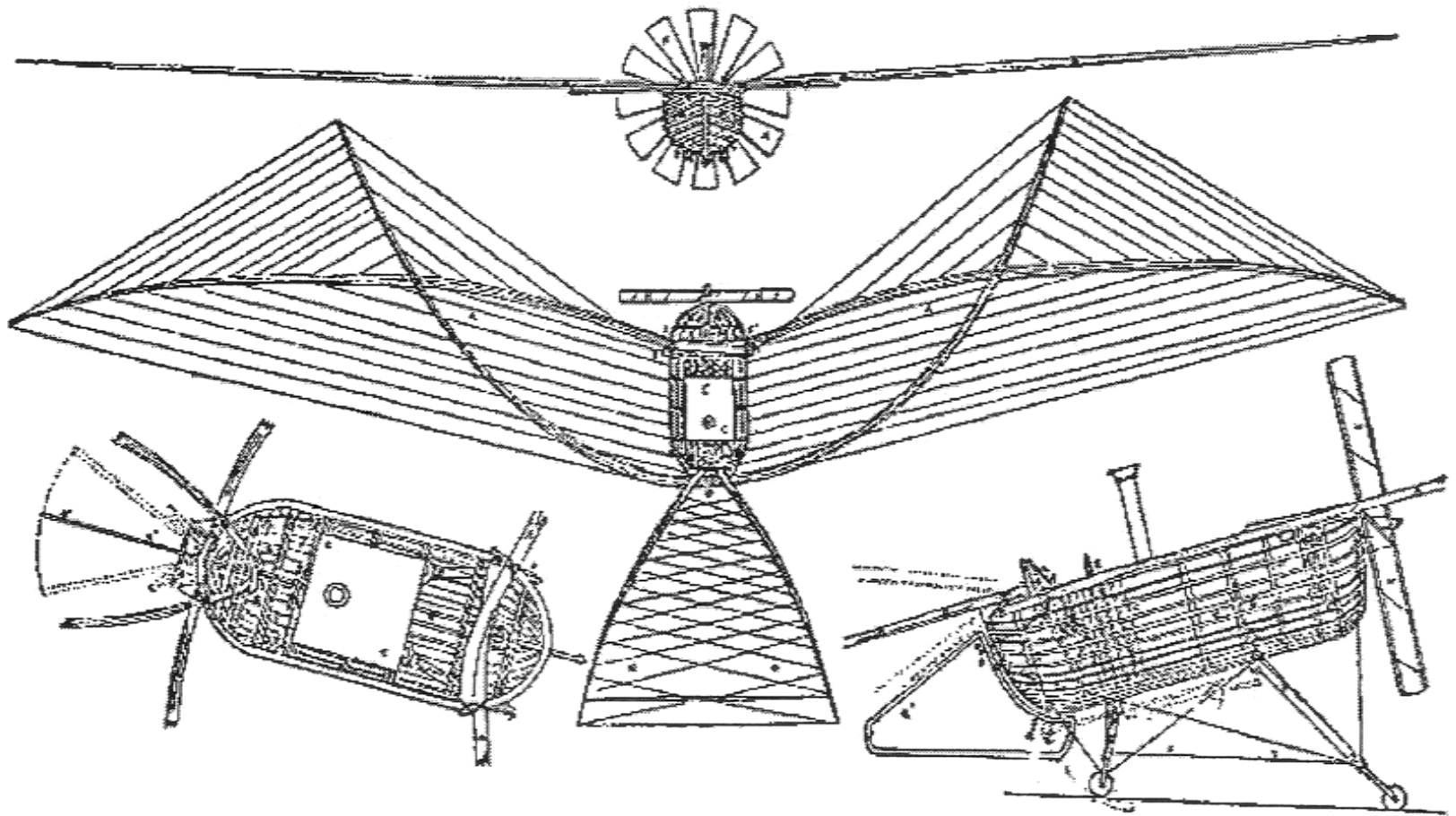
Introduction to Aerospace Propulsion

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IIT Bombay

Lecture No - 2

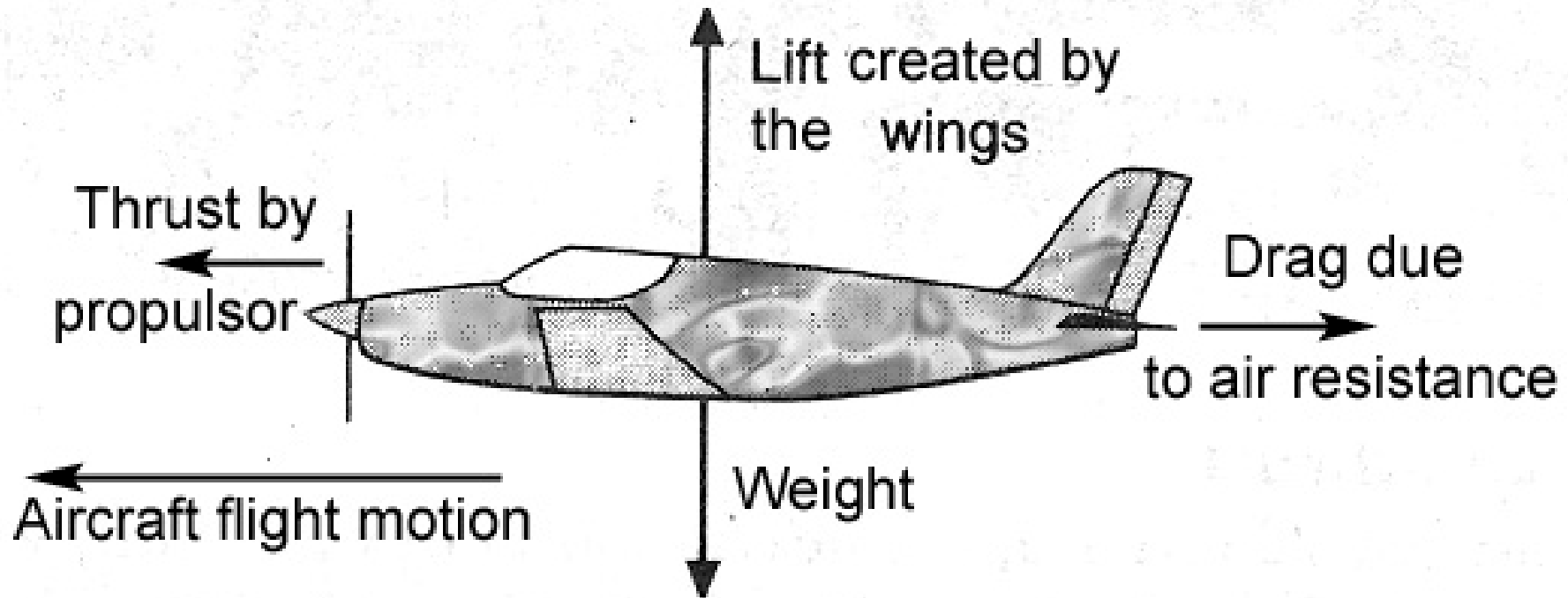




Felix Du Temple de la Croix – Monoplane 1857

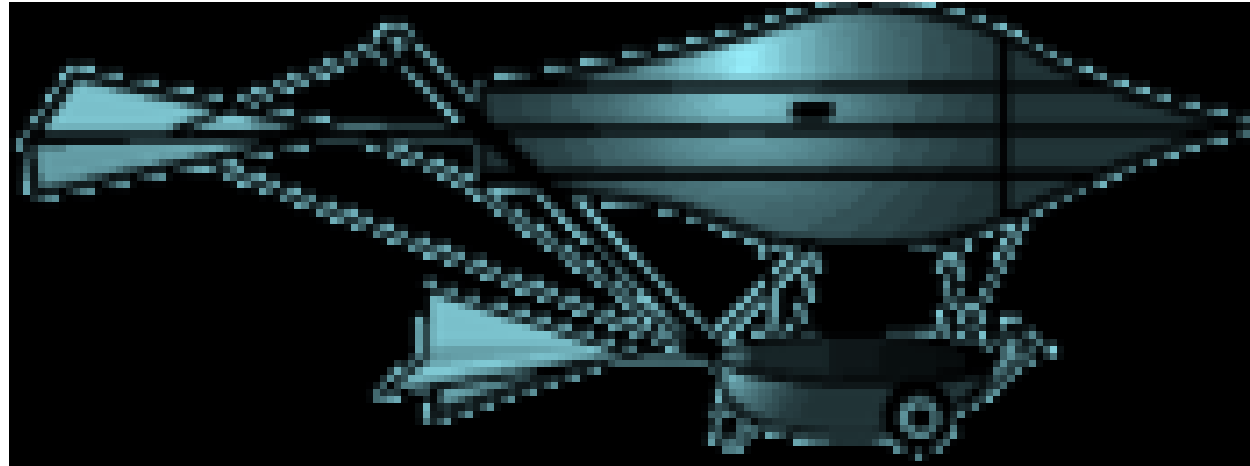
Thrust for Flight

In normal cruise flight $L=W$ and $T=D$ as force equilibrium

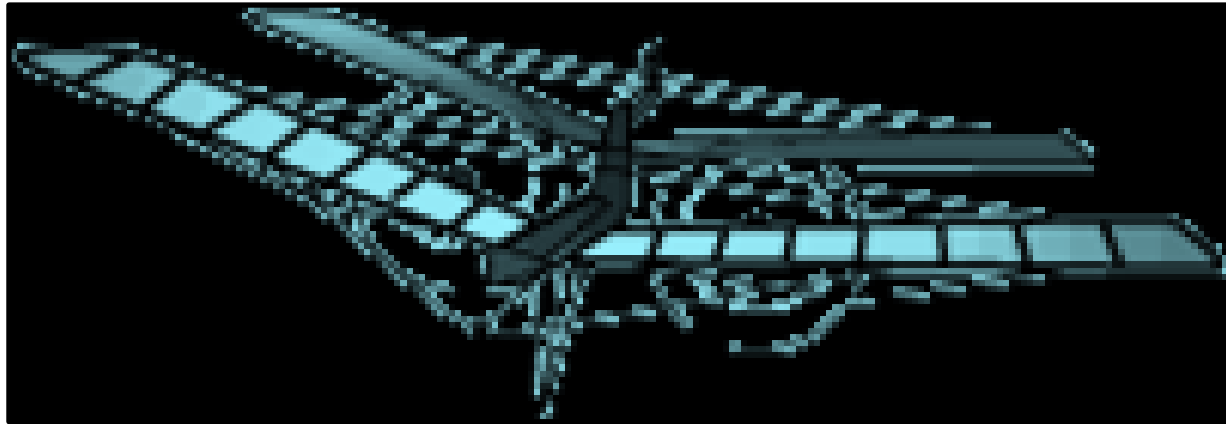


Unpowered airplanes

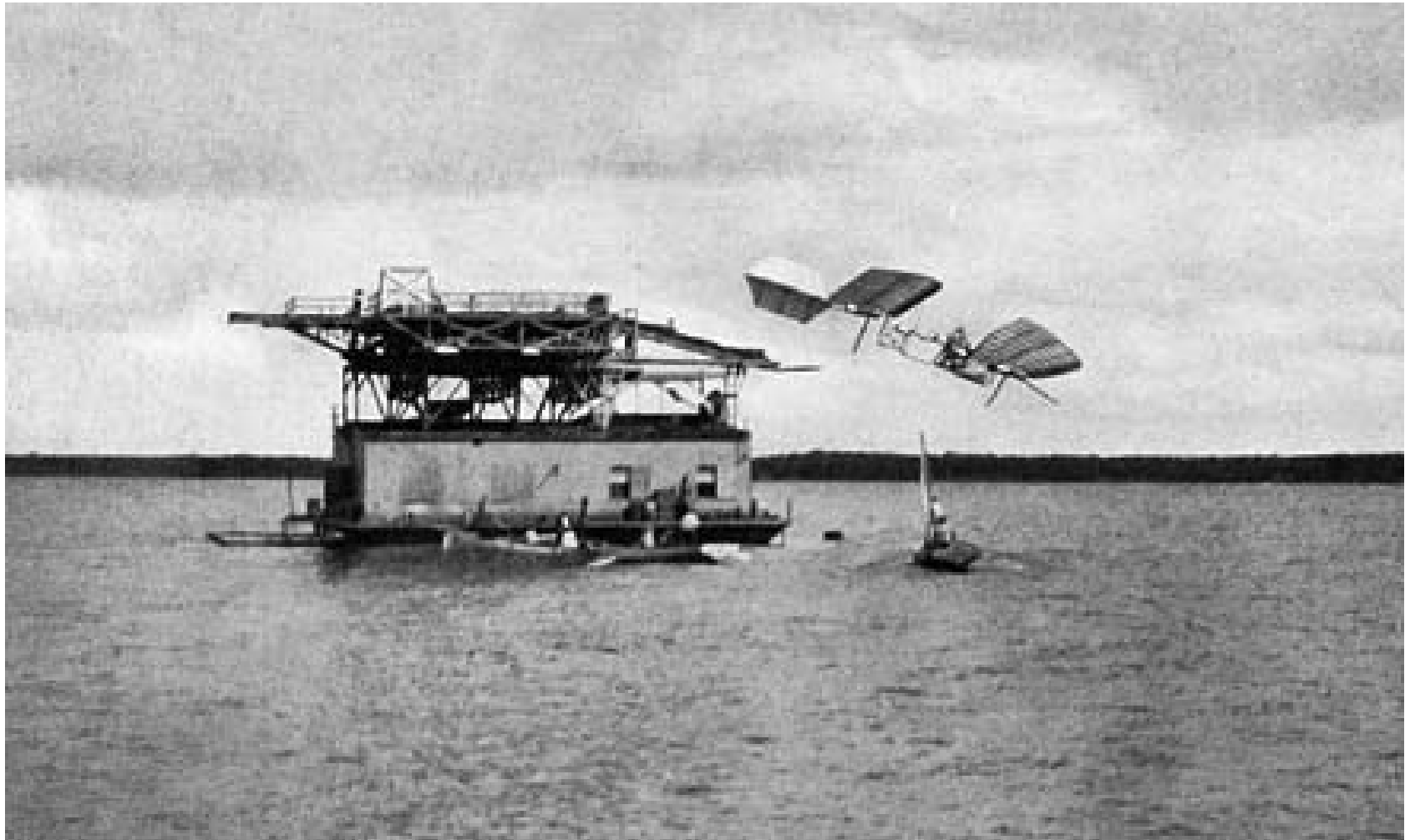
George Cayle's
design (early
19th century)

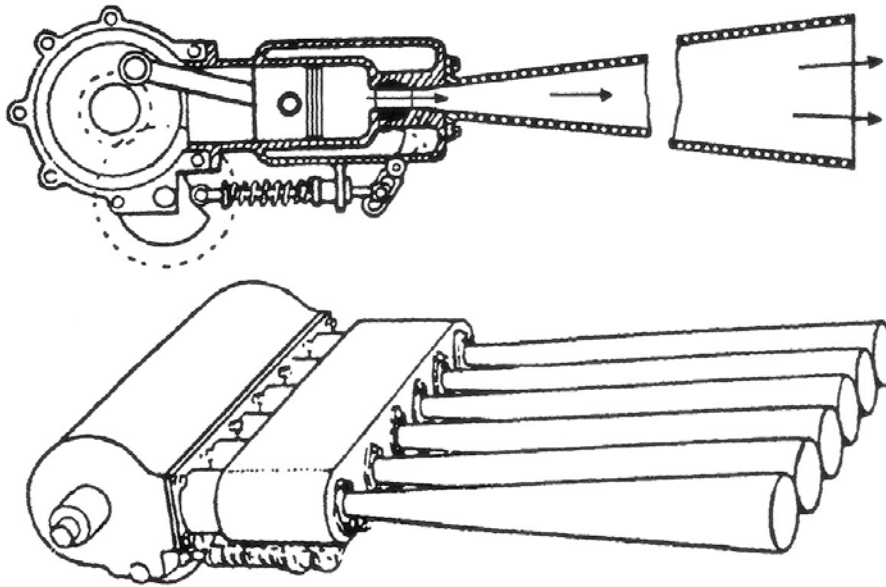


Samuel P
Langley's
Airplane (late
19th century)

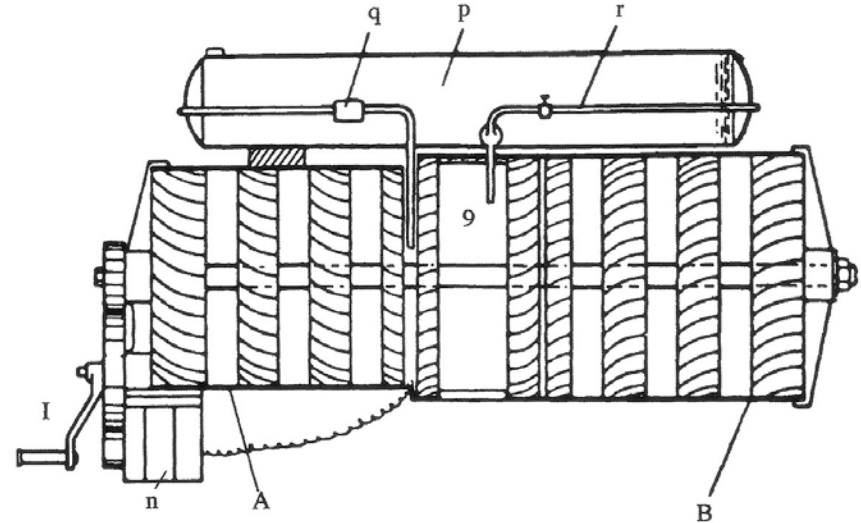


Langley's Airplane no Flight



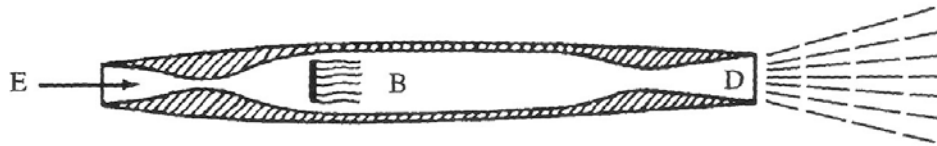


Lorin's 1908 patent.



1921 Guillaume patent.

Guillaume's Patent of a Jet Engine



Lorin's 1913 patent.

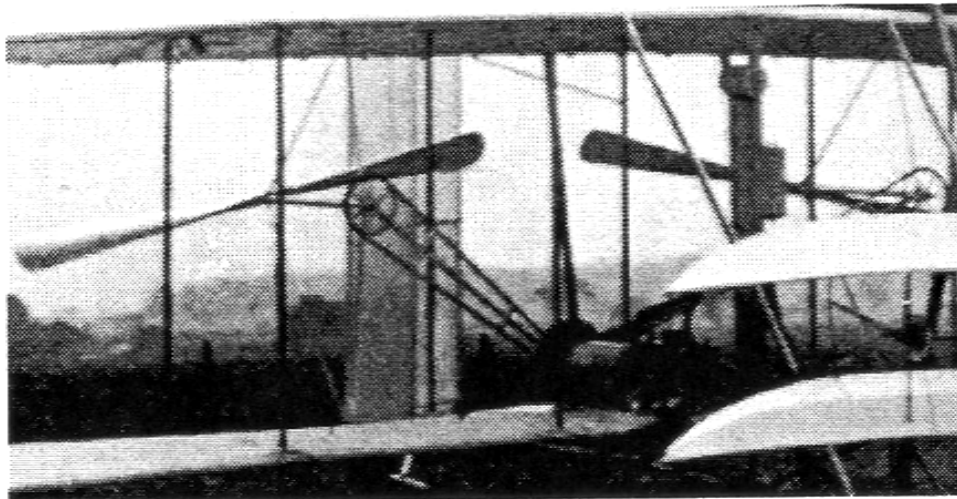
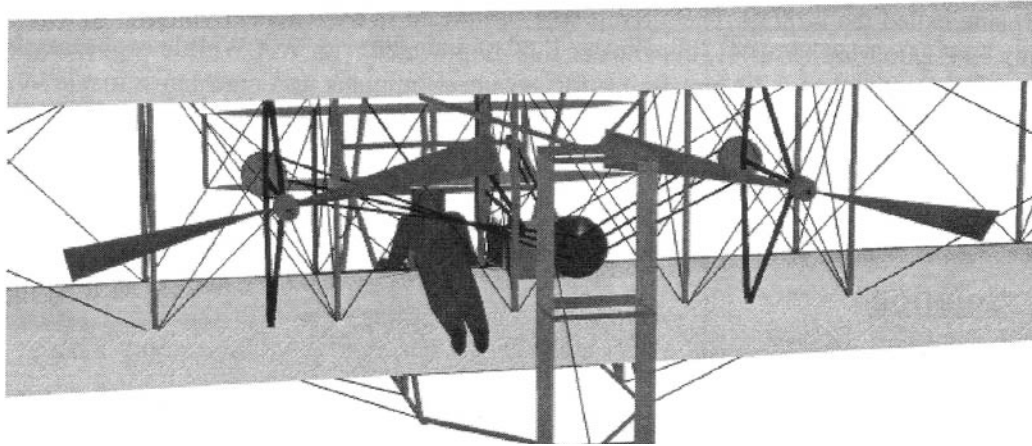
Lorin's Patent Drawings

First Flight 1903 Dec

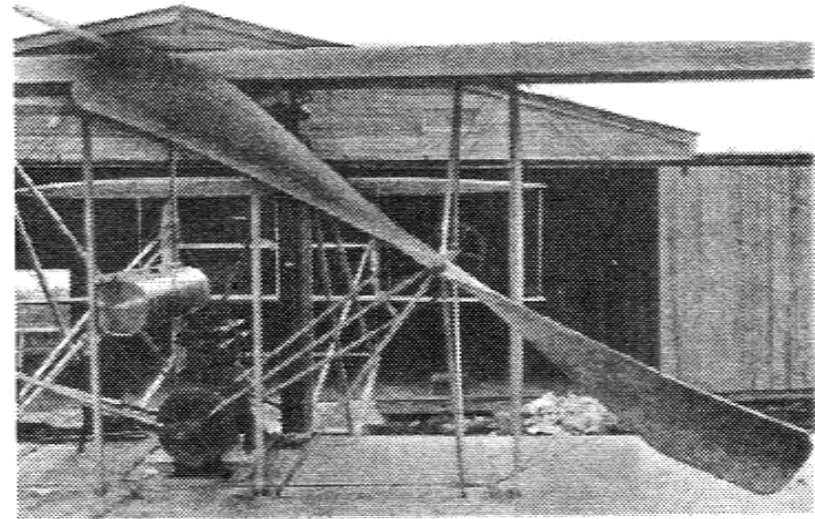






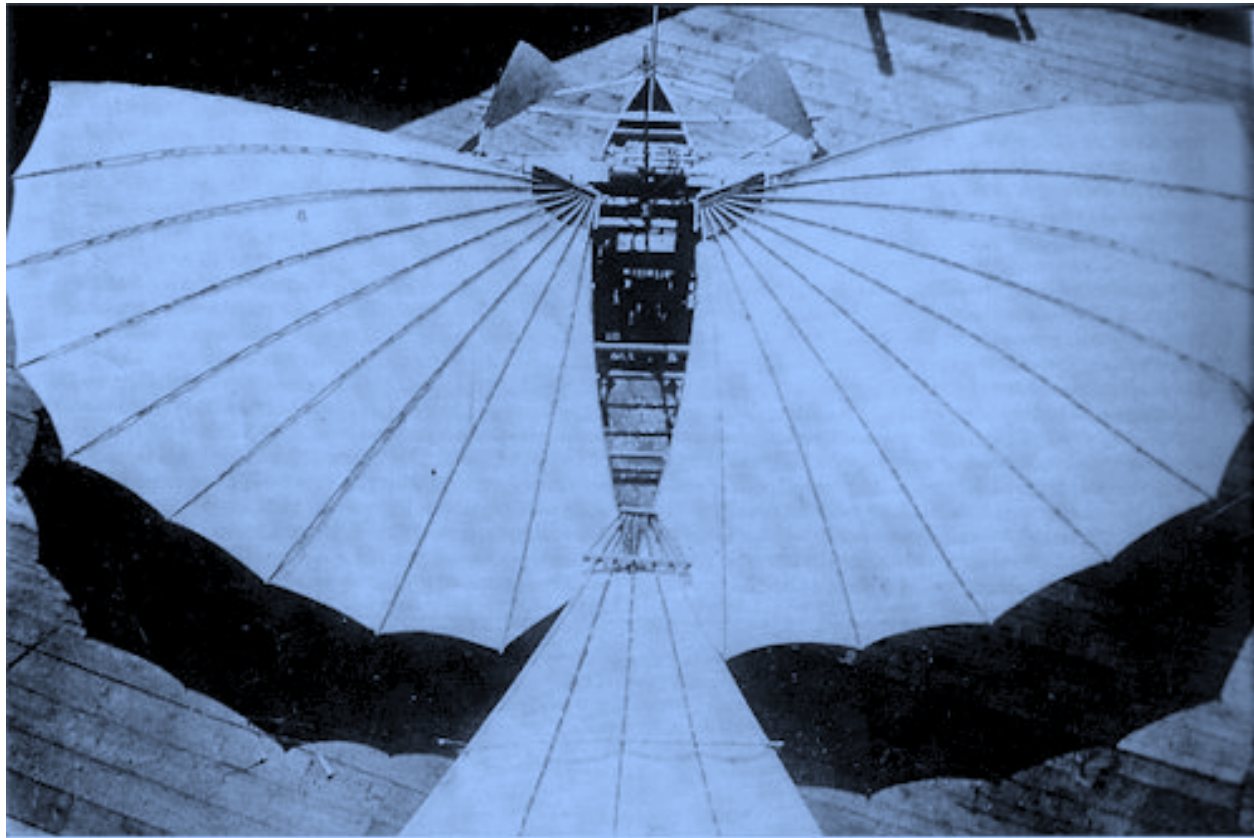


Wright's propeller 1903



Wright's Propeller 1910

2 years, 4 months and 3 days before the successful flights of the Wright brothers, a monoplane took to the air at early dawn on August 14, 1901, at Bridgeport, Conn, USA carrying the inventor, Gustave Whitehead, a distance of $\frac{1}{2}$ mile.

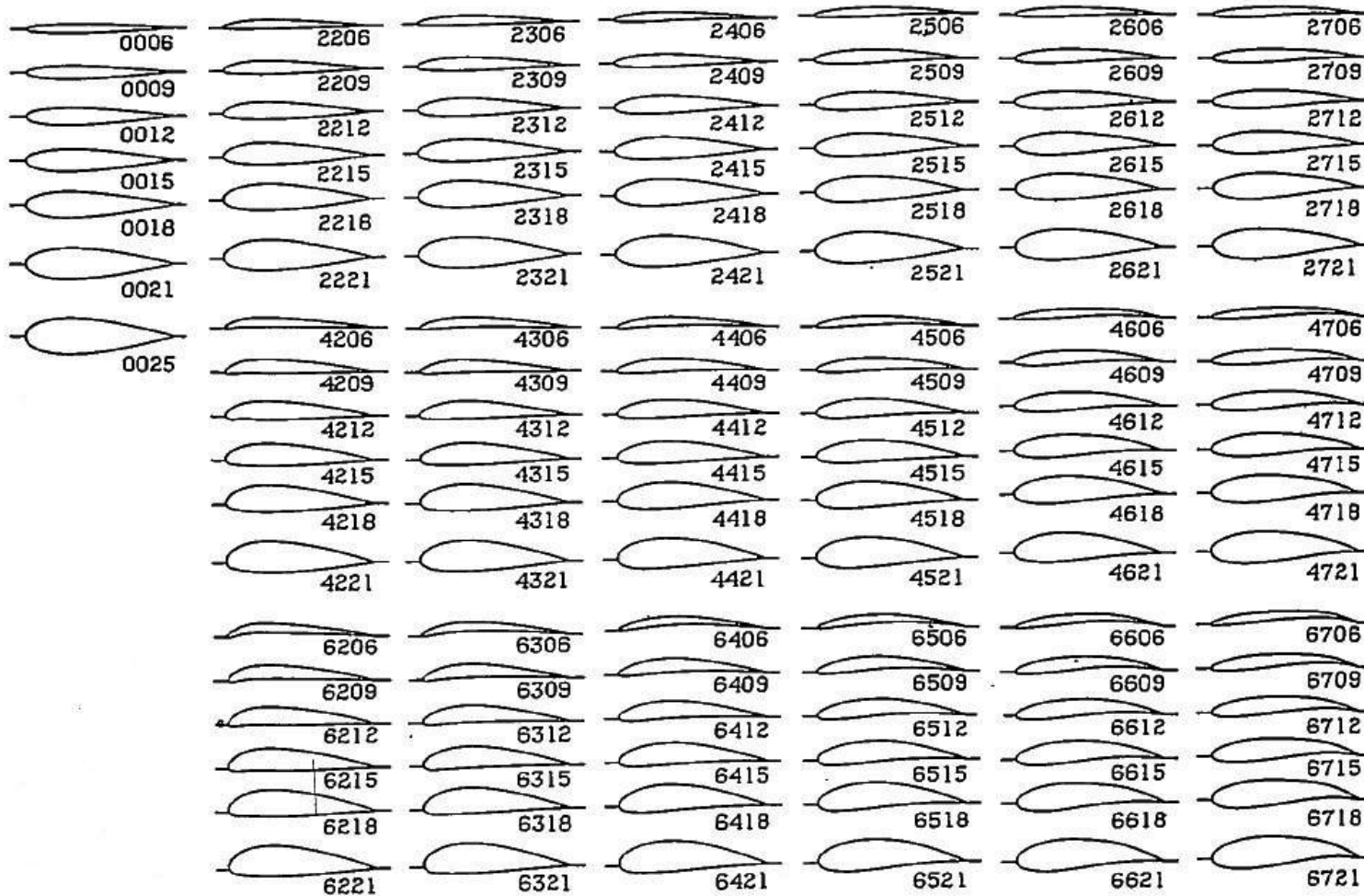


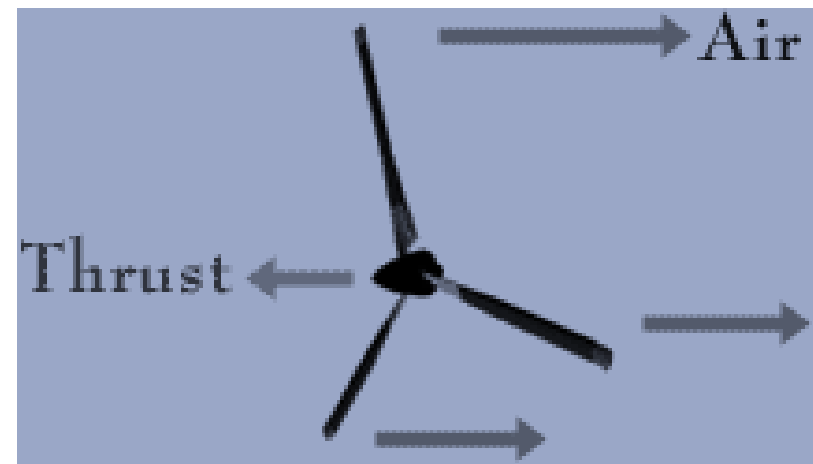
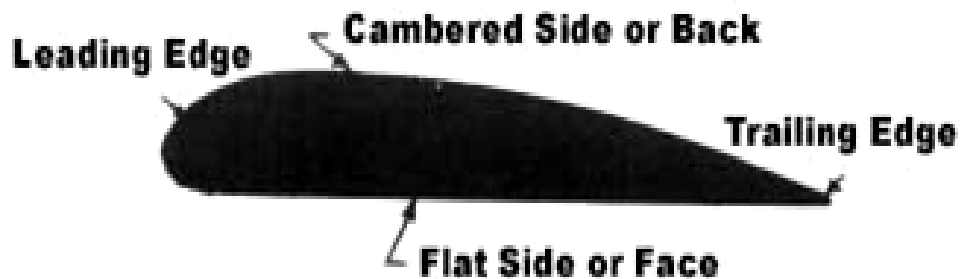
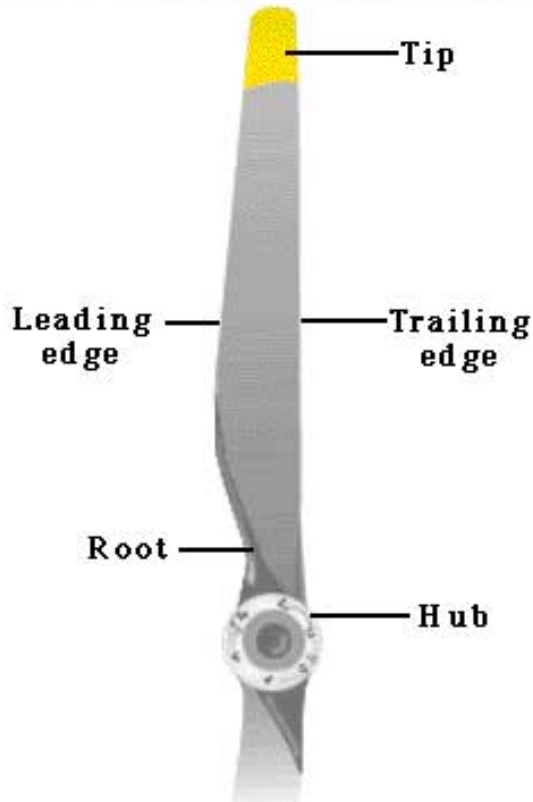
- For the first fifty years of flight all flight vehicles were using propellers as the only means of propulsion through air.
- **After I world war a high powered committee in USA had decided that flight with jet propulsion was not possible.**
- As a result NACA (precursor to present NASA) was entrusted in 1940's with creating a large number of propeller blade airfoil shapes.

Propeller Blade uses airfoil shapes

A propeller uses a type of airfoil (similar to a wing) that turns and accelerates air. As the blades of the propeller rotate they create lifting forces (just as a wing does), in the horizontal plane instead of the vertical as with the wings. Thus, the propeller creates a propulsive action force perpendicular to its plane of rotation, that moves the aircraft forward in air as a reaction. Propellers can either "pull" the aircraft from the the front of the wings / fuselage (**Tractor**) , or "push" it from behind (**Pusher**).

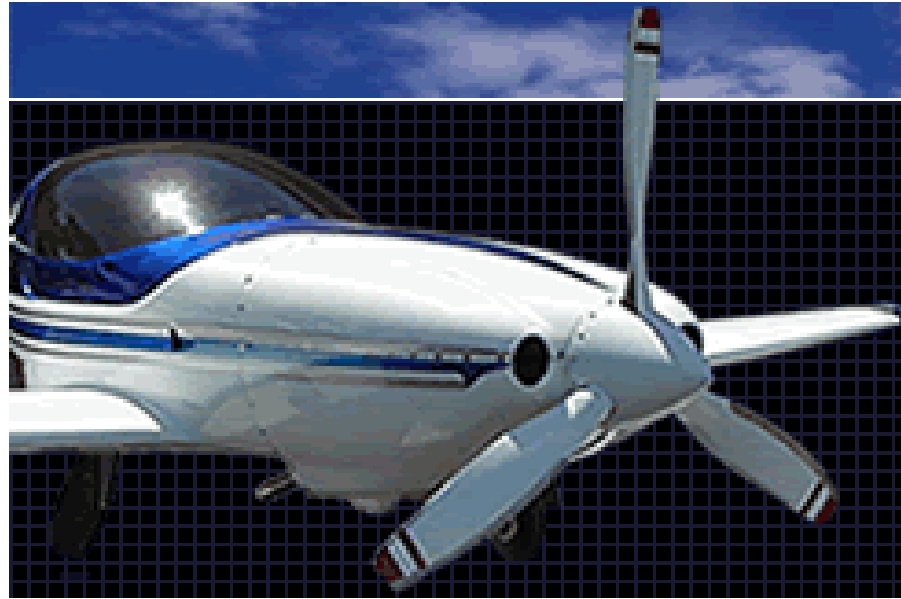
Propeller Blade airfoil shapes (NACA)







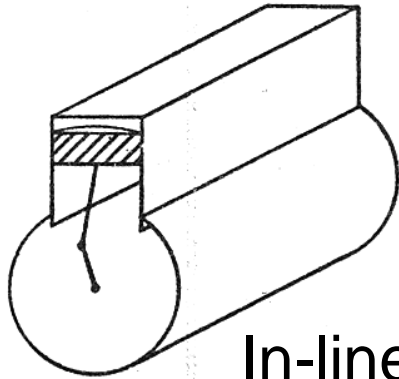
Propeller undergoing a wind tunnel testing



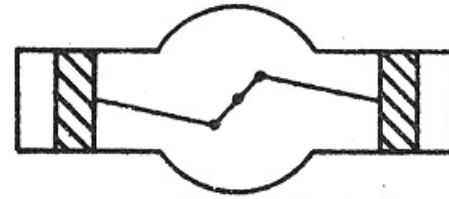
Tractor type propeller



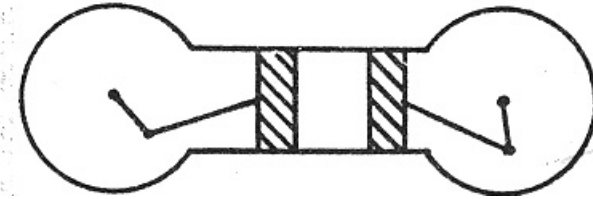
Pusher Propeller



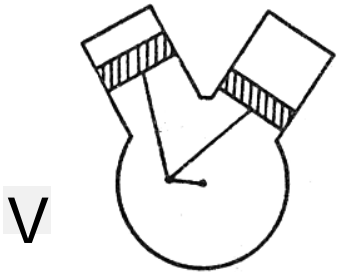
In-line



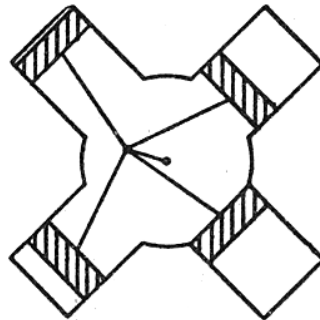
Opposed cylinder



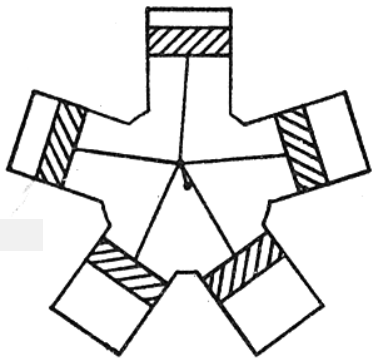
Opposed Piston



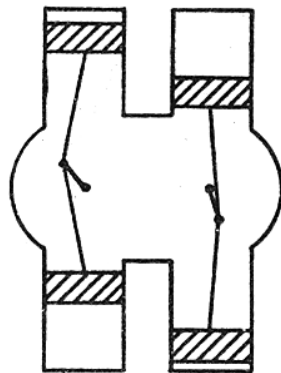
V



X

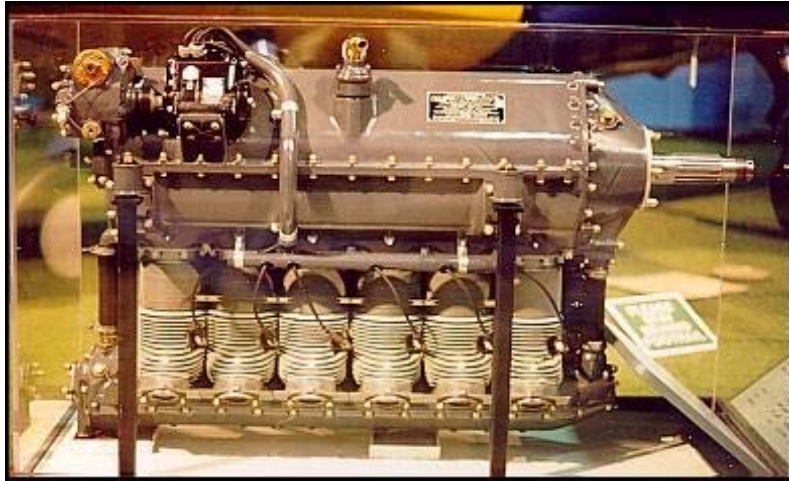


Radial



H

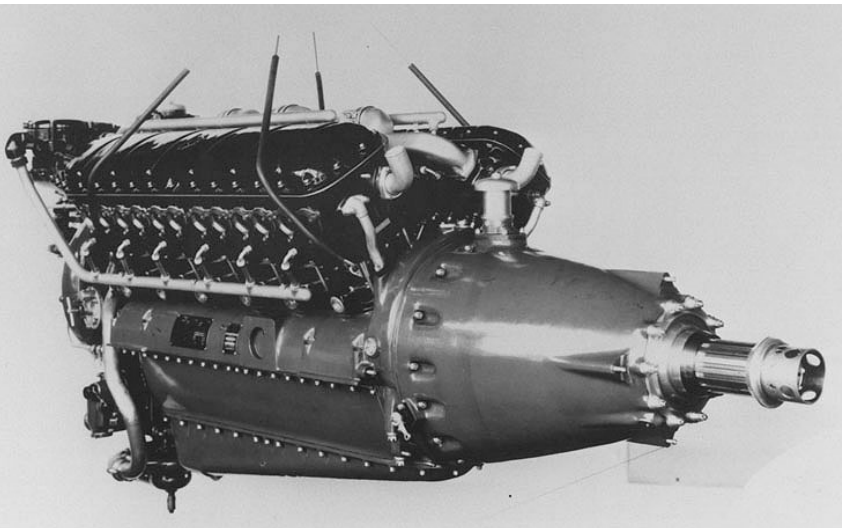
IC (piston) Engine
– multi-cylinder
arrangements for
Aircraft Propulsion



In-line



Opposed cylinder

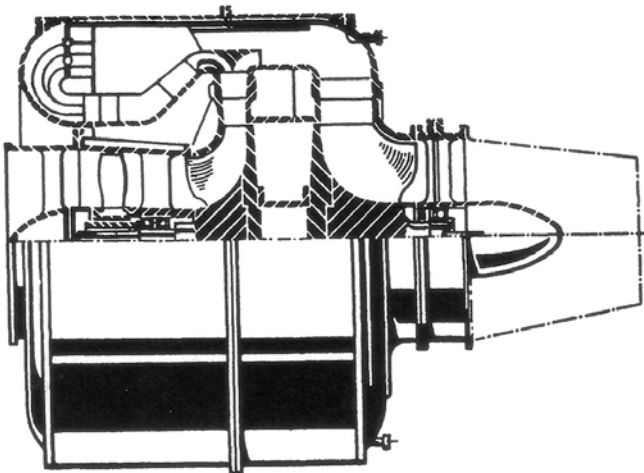


V-type

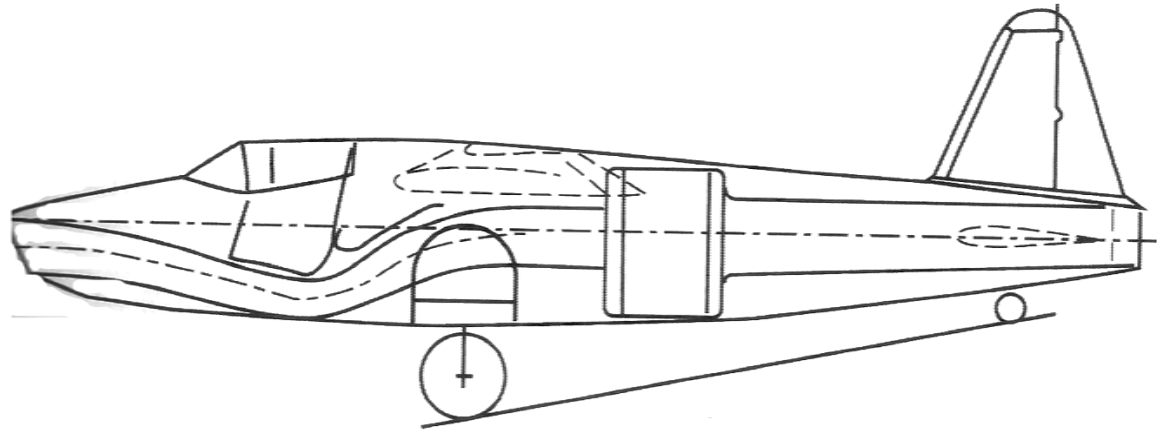


Radial

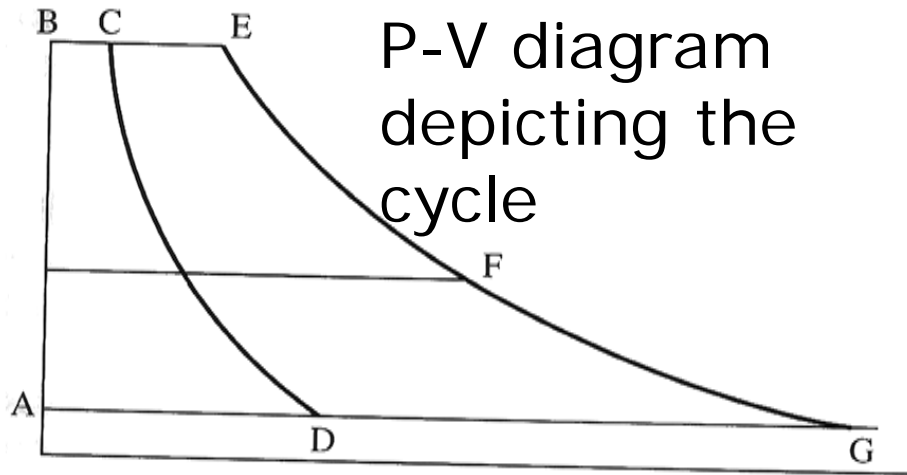
Jet Engines 1930s - 40s



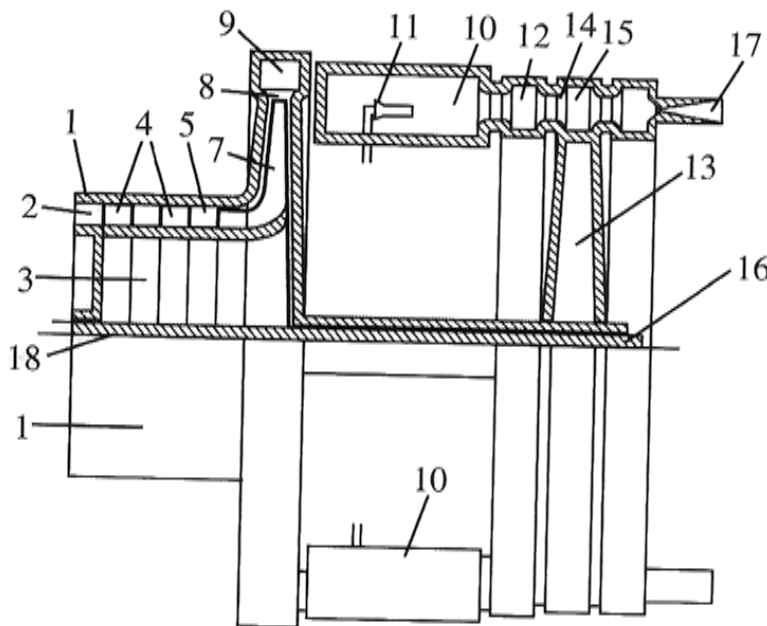
Heinkel Engine



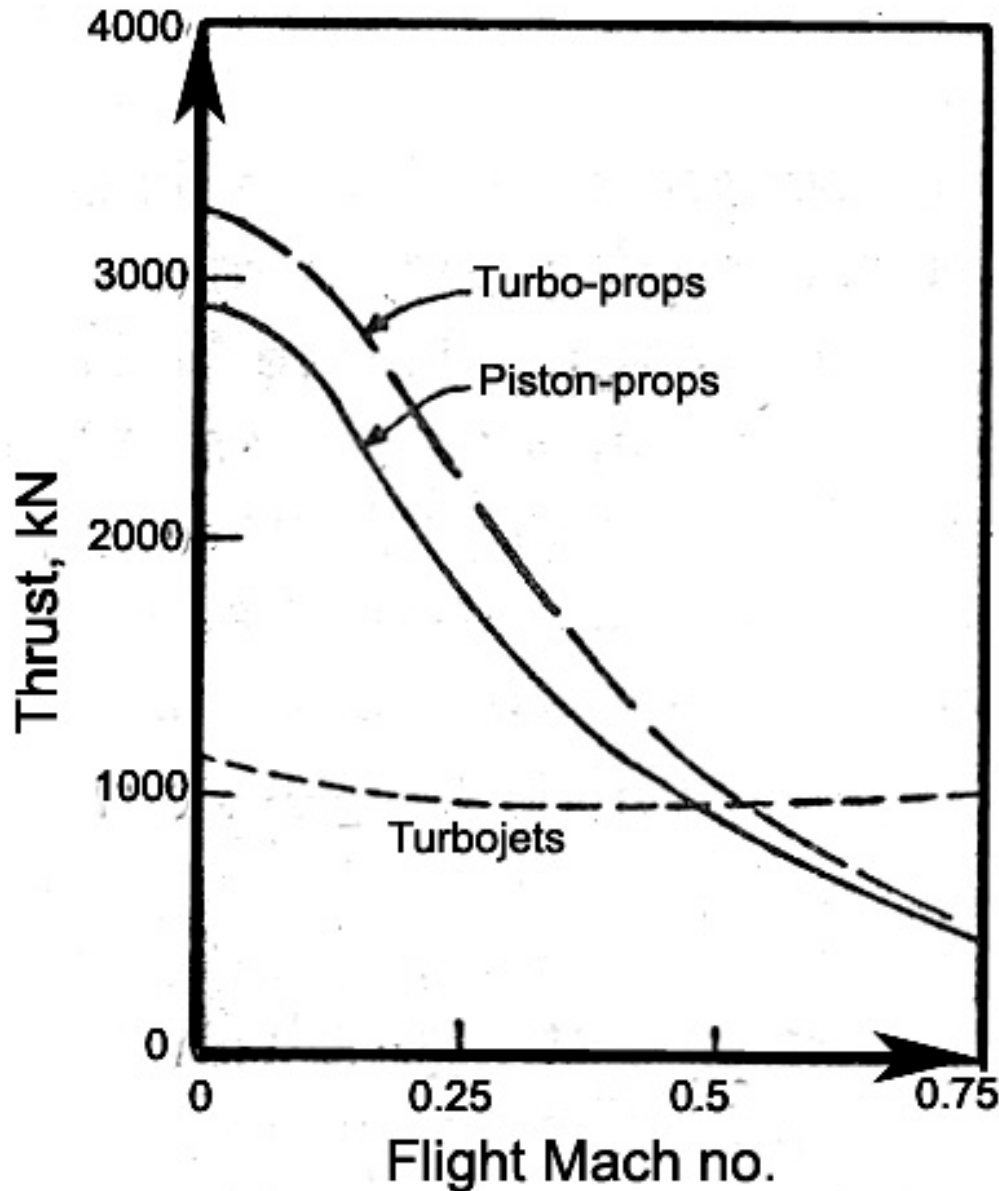
Heinkel He 178 First Jet engine powered aircraft



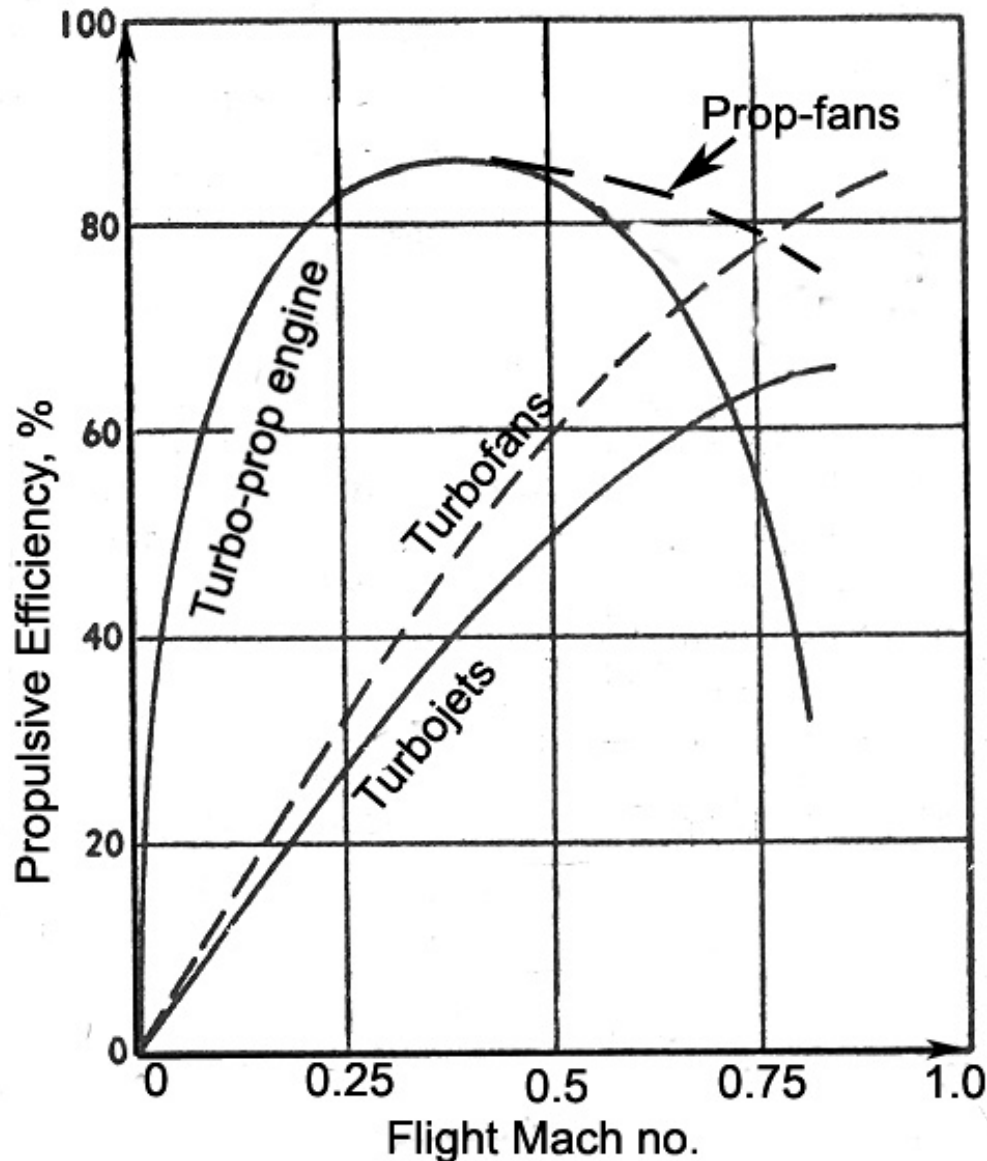
Frank Whittle's engine design for patent



- 2 - Air Intake**
- 3 - Rotor Disks**
- 4,5 - Axial Compressor rotors**
- 7 - Centrifugal compressor**
- 10 - Central Shaft**
- 11 - Combustion Chamber**
- 15 - Axial Turbine rotor**
- 17 - Exit nozzle**



Comparison of various kinds of Aircraft Powerplants



Comparison of various kinds of Aircraft Powerplants

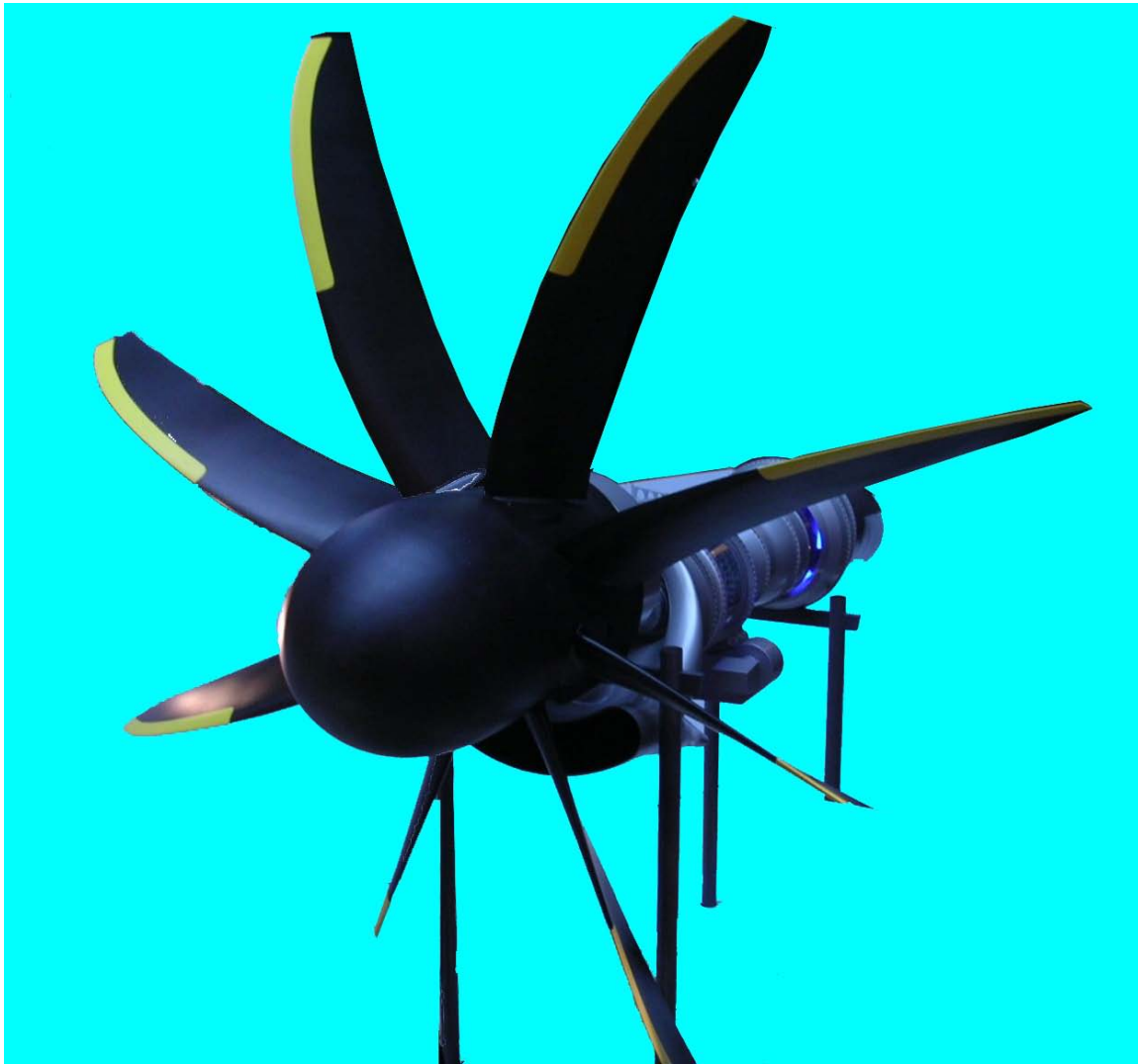
Propulsive efficiency is a measure of end usage of available energy for final thrust creation. It is not same as the thermal or overall efficiencies of an engine

Modern aircraft powerplant designers are using Prop-fans or Prop-jets that enable usage of propellers for high thrust and high efficiency at low Mach number flights (for take-off and climb) and then use essentially jet propulsion for cruise at high Mach number and high altitude

The Thrust generation

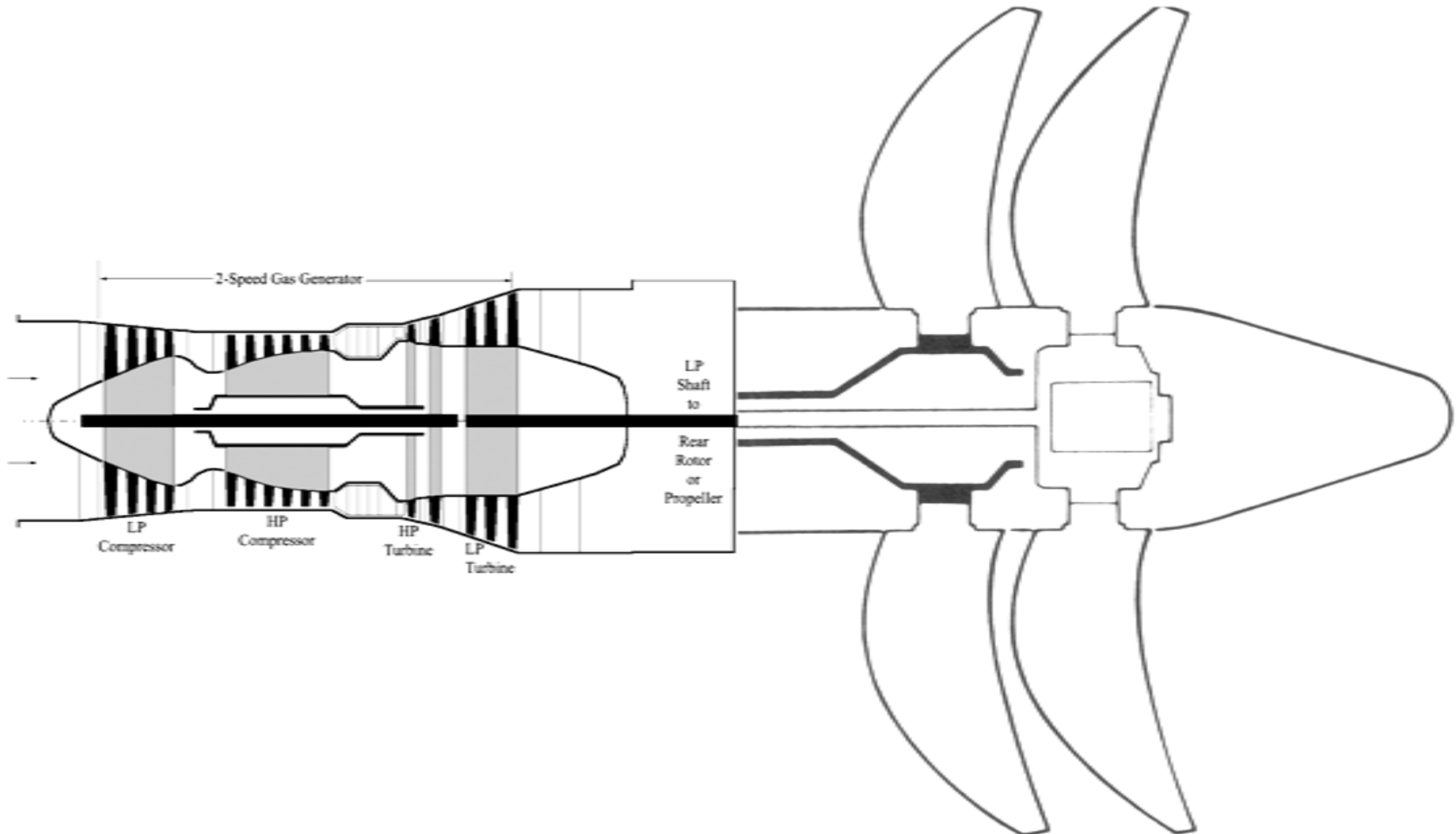
$$F = \frac{dM_t}{dt} = \frac{d(mV)}{dt} = m \frac{dv}{dt} = \frac{m}{dt} dv = \dot{m} \cdot dv$$

- High mass activation(air), \dot{m} – Propellers
– low dV
- High change of momentum, dV - Jet engines
– low mass activation, \dot{m}
- Propellers typically operate on air mass flows 30 to 40 times more than that of a jet engine.

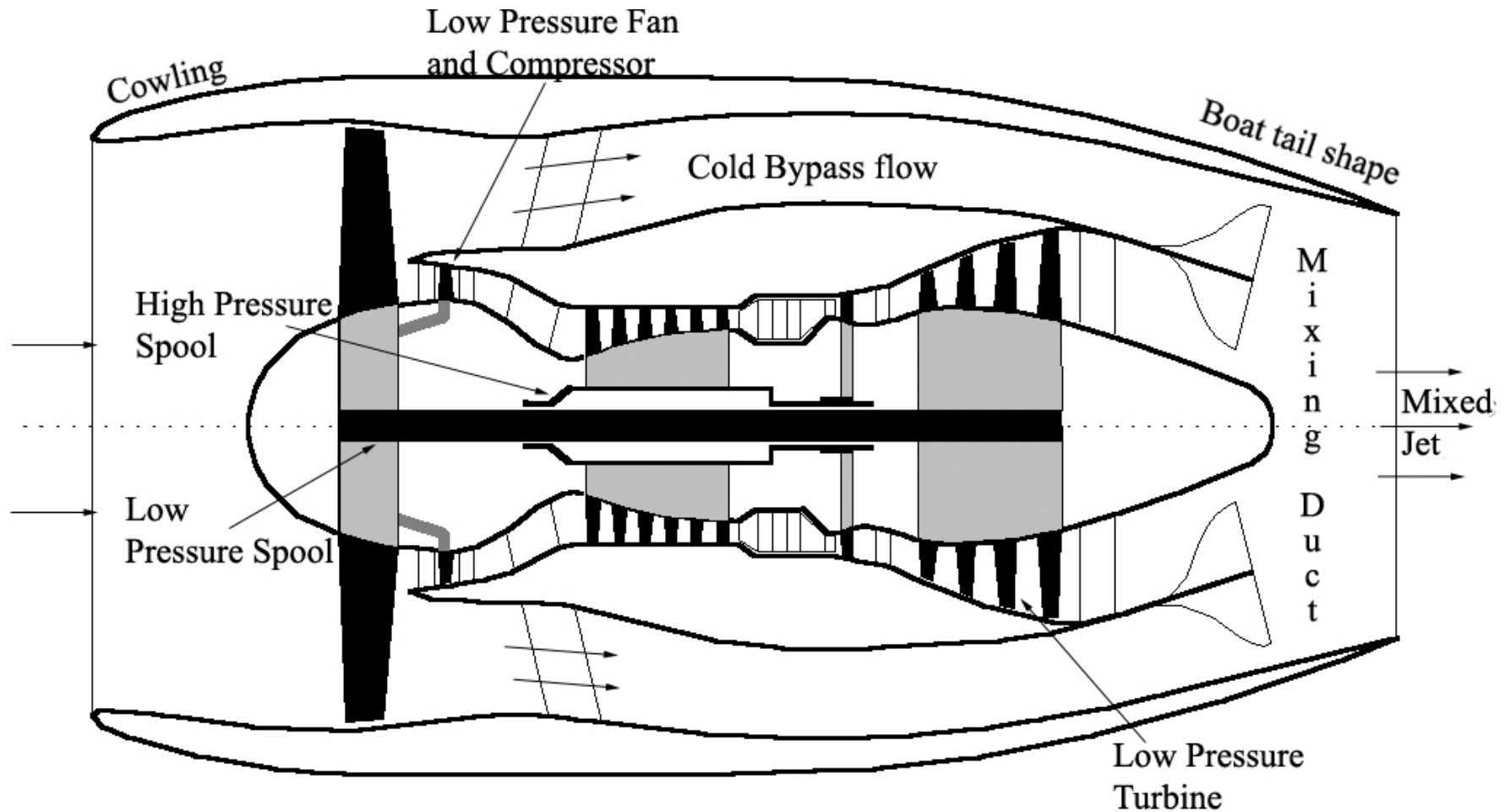


**A modern
propeller**

Prop-Fan uses a basic engine



Modern Jet Engine



Abbreviation :

NACA : National Advisory Committee for
Aeronautics, USA

NASA: National Aeronautics and Space
Administration, USA

ISRO : Indian Space Research Organisation, India

HAL : Hindustan Aeronautics Limited, India