

# Turbomachinery

The Revolution of Modern Flight



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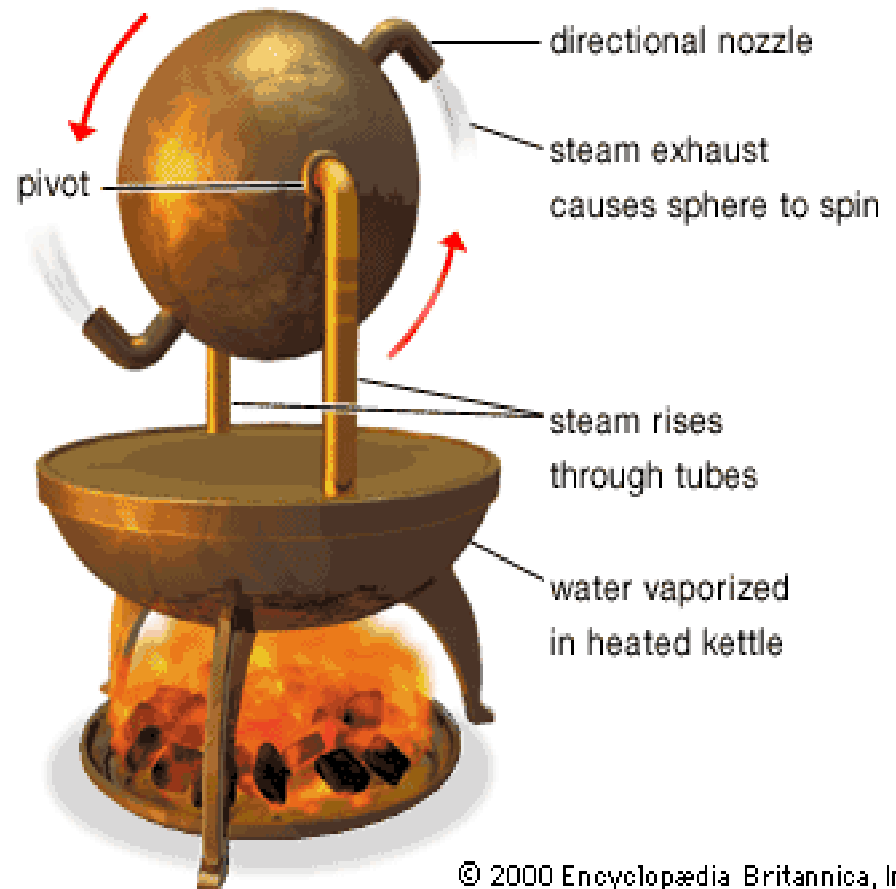
# General Information

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- Turbomachinery: Rotating machinery incorporating a turbine that operates through the action of rows of blades in order to add or remove mechanical power from a continuously flowing stream of fluid
- Used to attain speeds from much less than Mach 1 all the way to Mach 24(theoretical)
- Efficient in moving large and heavy objects a large distance
- Used in various applications and machines:
  - Generators
  - Aircraft
  - Cars
  - Ships
  - And more

# History

- During the 1st century, Hero of Alexandria invented the aeolipile
- Uses steam to power jets that turn a metal sphere
- Aeolipile demonstrates the first use of jet propulsion principles



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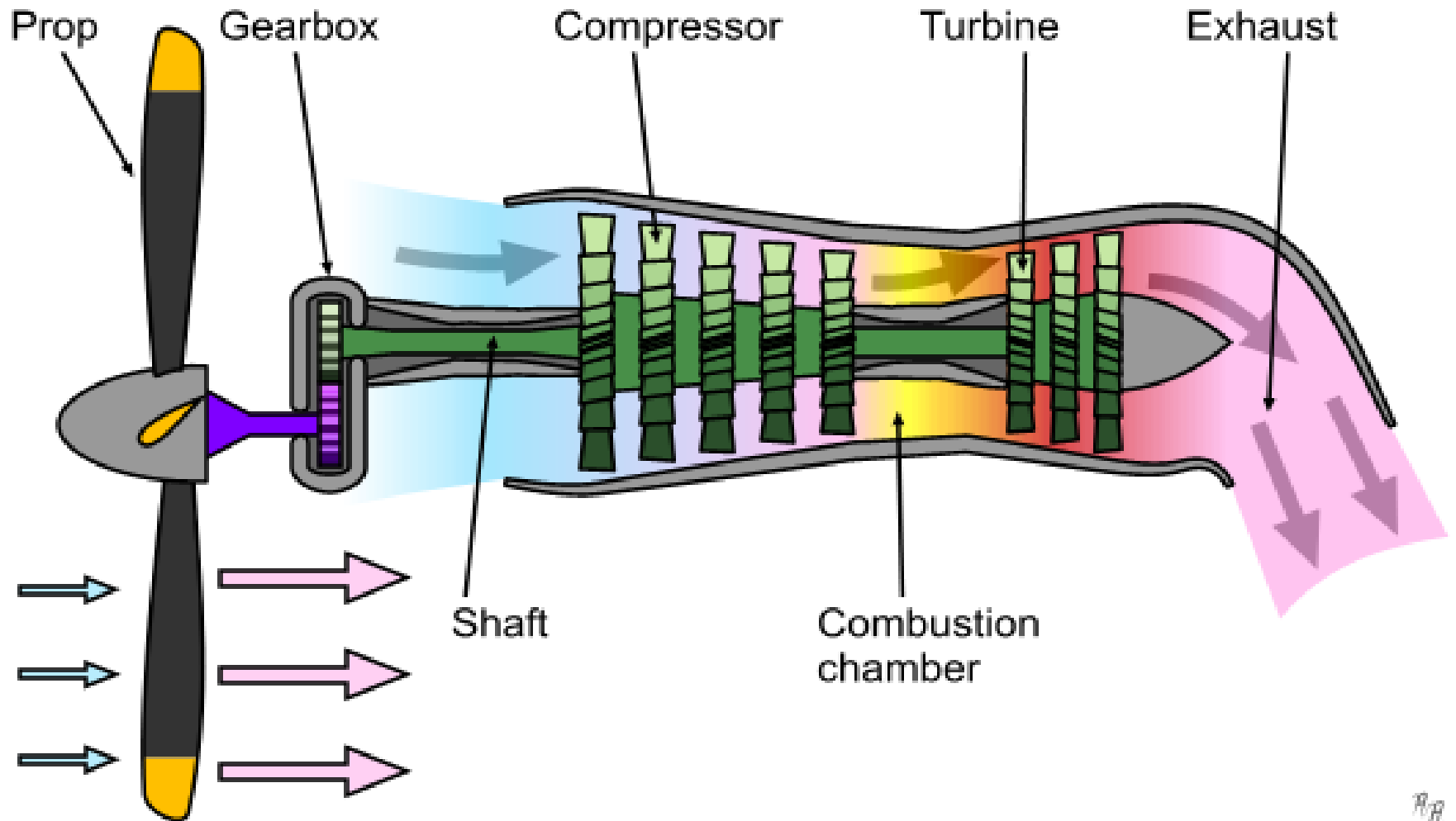


# Turboprop: How it works

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- The first turboprop engine was designed by György Jendrassik, a Hungarian mechanical engineer
- Consists of an intake, compressor, combustor, propeller, turbine and a propelling nozzle
- Most of the engine power is used to drive the propeller
- Some engine power is used to spin the compressor
- About 10% of the engine power is expelled as exhaust
- Used in flight speeds from Mach 0.2 to 0.7
- Most efficient at moderate flight speeds (450 mph)
- Is mainly employed in small commuter aircraft

# Turboprop: Diagram



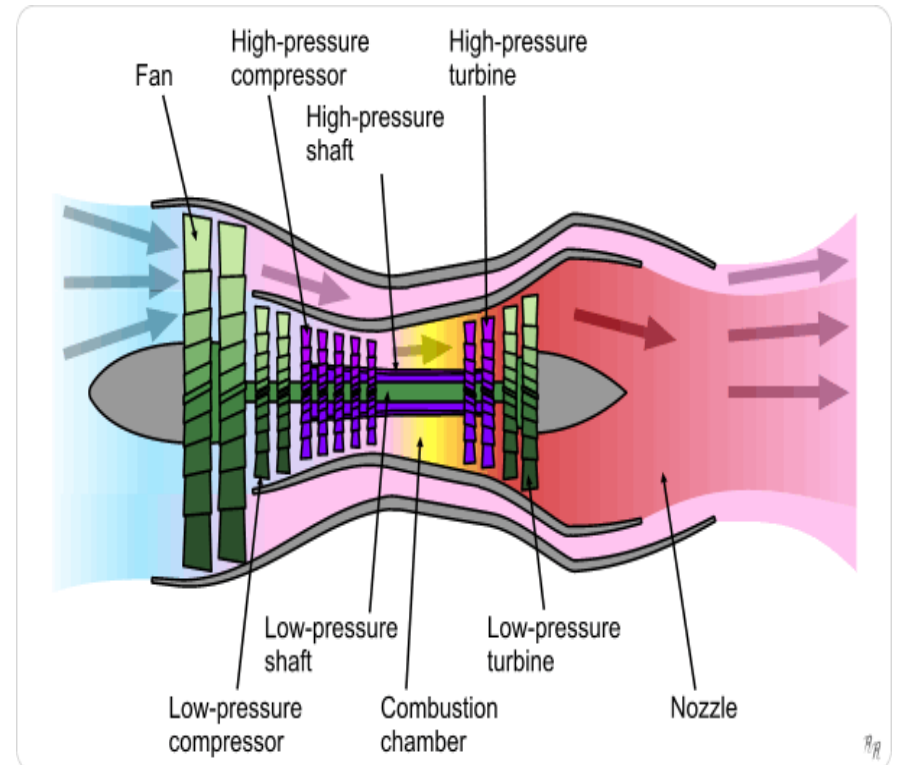
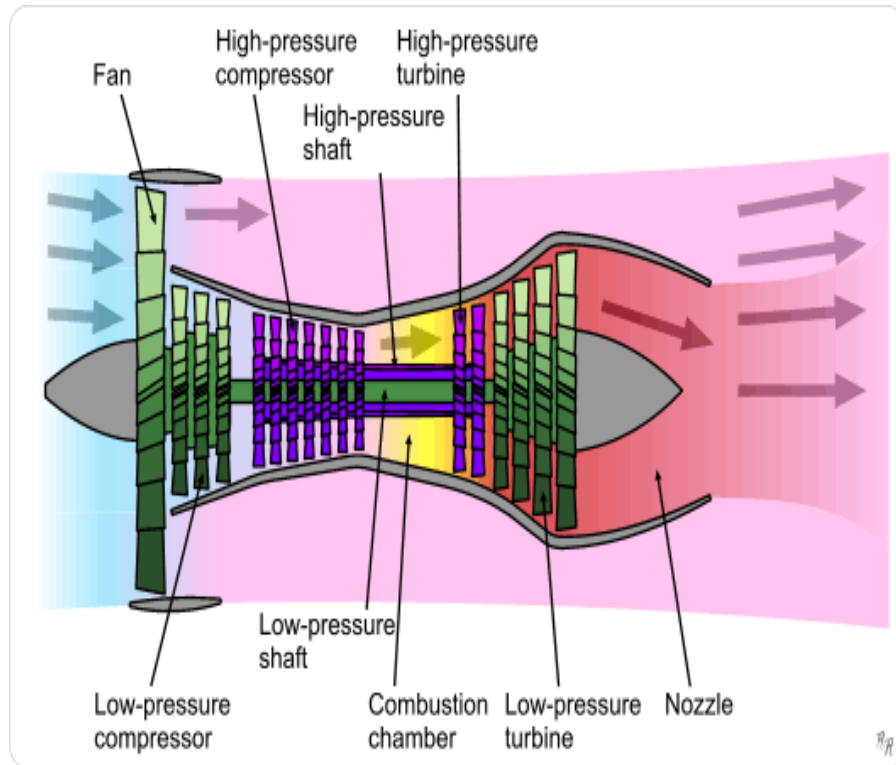


# Turbofan: How it works

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- The Daimler-Benz DB 670 was the first turbofan, which was operated on April 1, 1943.
- Used in flight speeds from Mach .75 to .9
- Purpose of the fans are to create high bypass ratios for subsonic flight
- Bypass airflow produces greater thrust while reducing specific fuel consumption
- Highly efficient and relatively quiet
- Classified according to their bypass ratios
- Trend tends towards higher and higher bypass ratios
- Primarily used in large commercial aircraft

# Turbofan: Diagram



[http://upload.wikimedia.org/wikipedia/commons/c/c0/Turbofan\\_operation.png](http://upload.wikimedia.org/wikipedia/commons/c/c0/Turbofan_operation.png)

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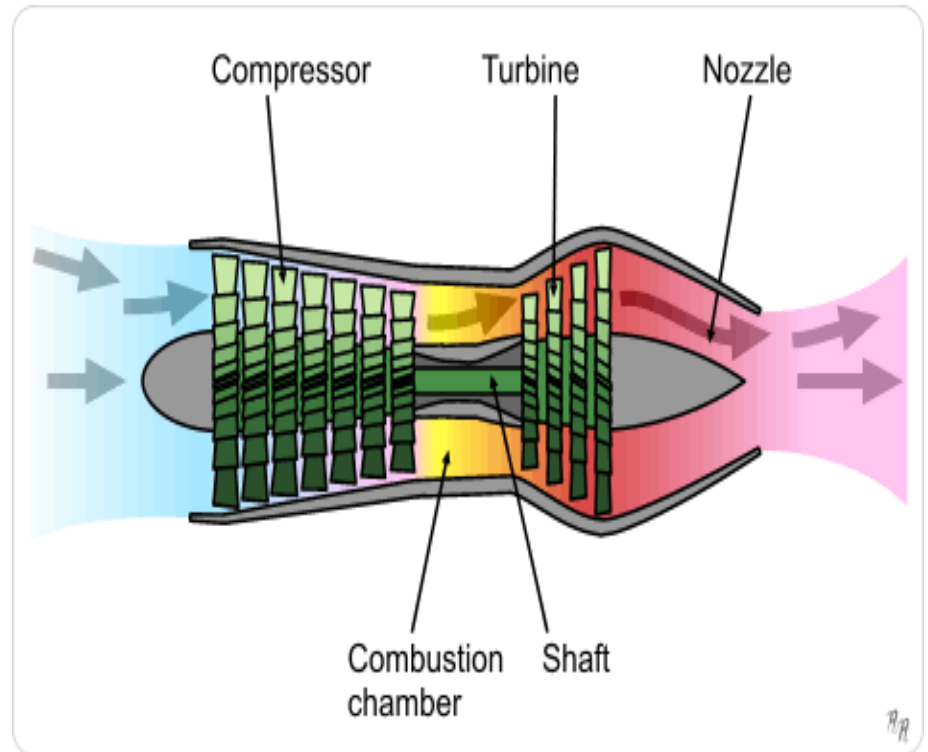
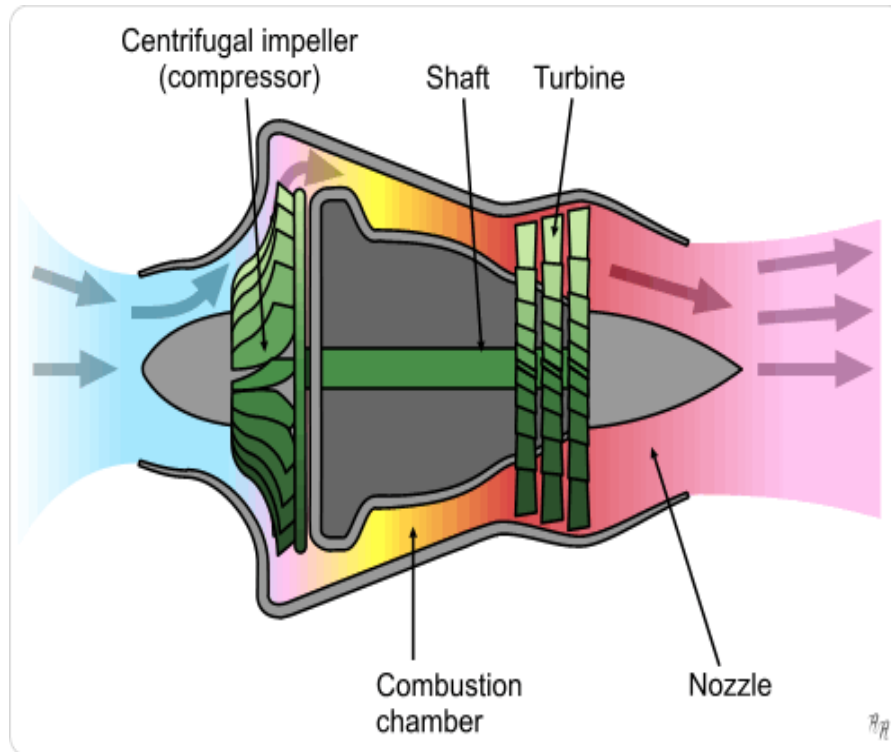


# Turbojet: How it works

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- Sir Frank Whittle from Britain and Hans von Ohain from Germany invented the turbojet in the 1930's
- The first turbojet airplane was the Heinkel He 178, the first operational jet was the German Messerschmitt Me 262, used at the end of WWII
- Parts: air intake, compressor, combustion chamber, turbine and nozzle
- Turbojets are low efficiency compared to the turbofan and turboprop and very noisy
- All of the power in the turbojet comes from the exhaust
- Jet engines have been mostly replaced by turbofans on commercial jets

# Turbojet: Diagram



[http://upload.wikimedia.org/wikipedia/commons/c/ce/Turbojet\\_operation-centrifugal\\_flow.png](http://upload.wikimedia.org/wikipedia/commons/c/ce/Turbojet_operation-centrifugal_flow.png)

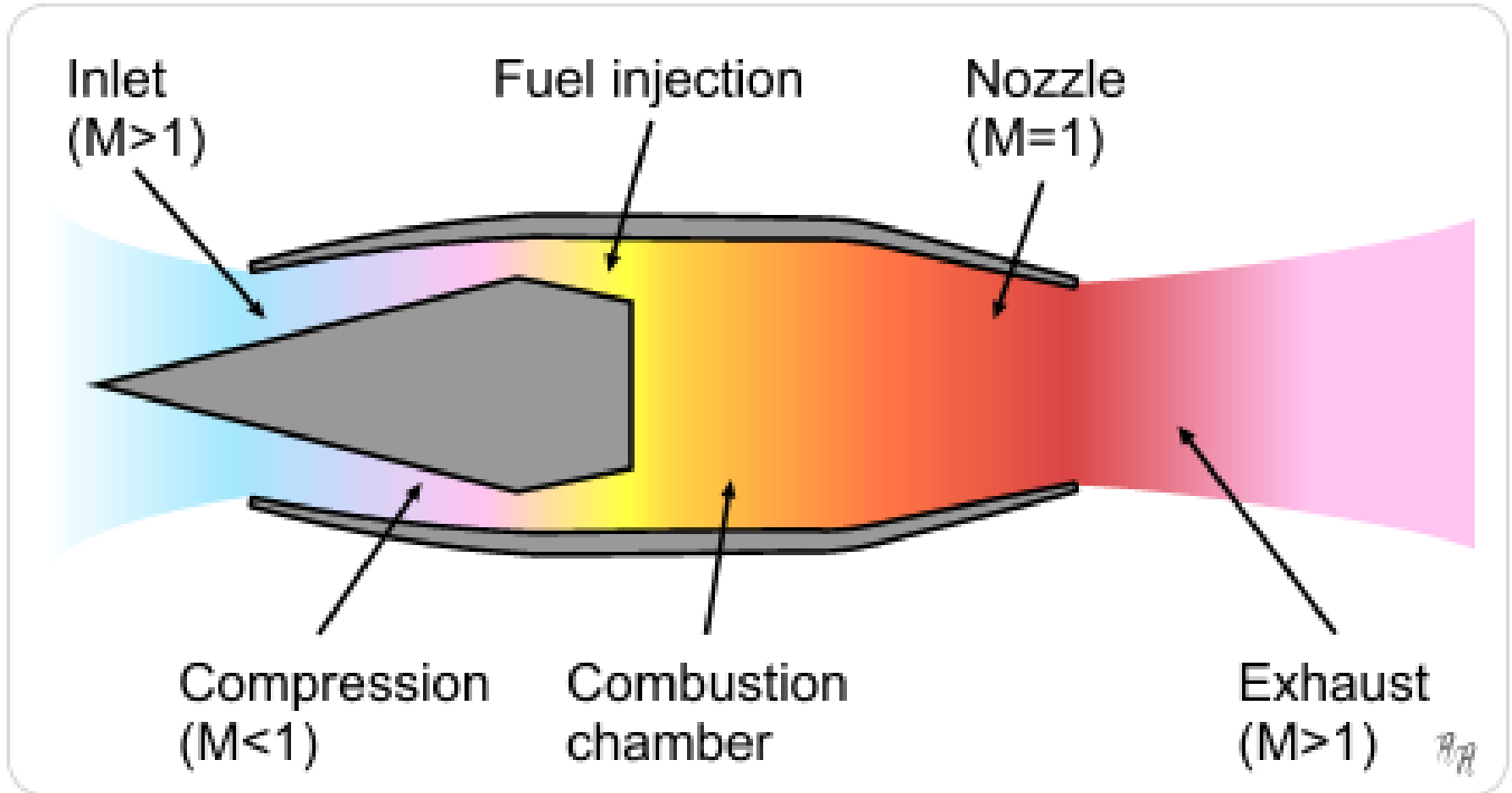


# Ramjet: How it works

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- Compresses air and reduces it to a subsonic speed
- Combustion takes place after compression
- Temperature and pressure of air increase causing it to accelerate
- Uses common jet fuel
- Unlike other engines, ramjet has no moving parts
- Works efficiently once it reaches minimum speed of 600 mph
- Top speed is limited to Mach 5.5
- Patented by René Lorin in 1908

# Ramjet: Diagram



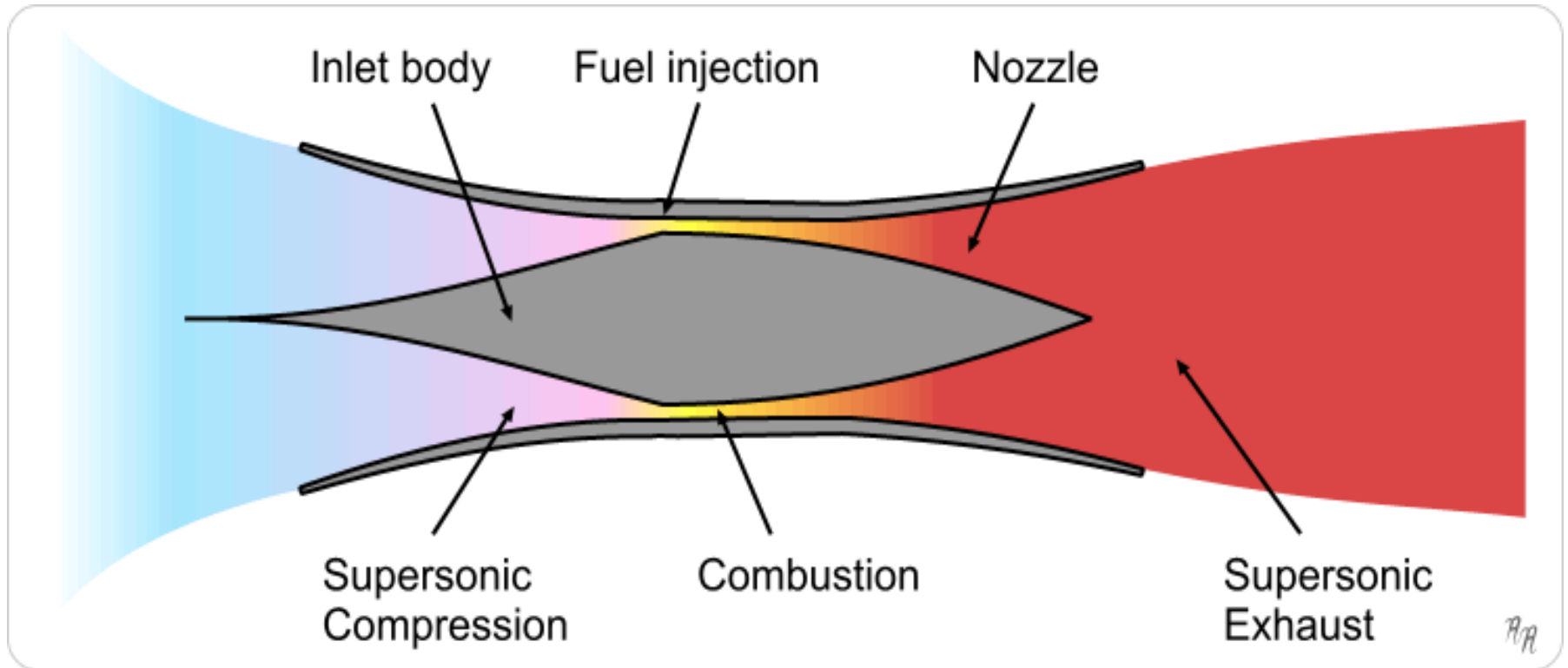


# Scramjet: How it works

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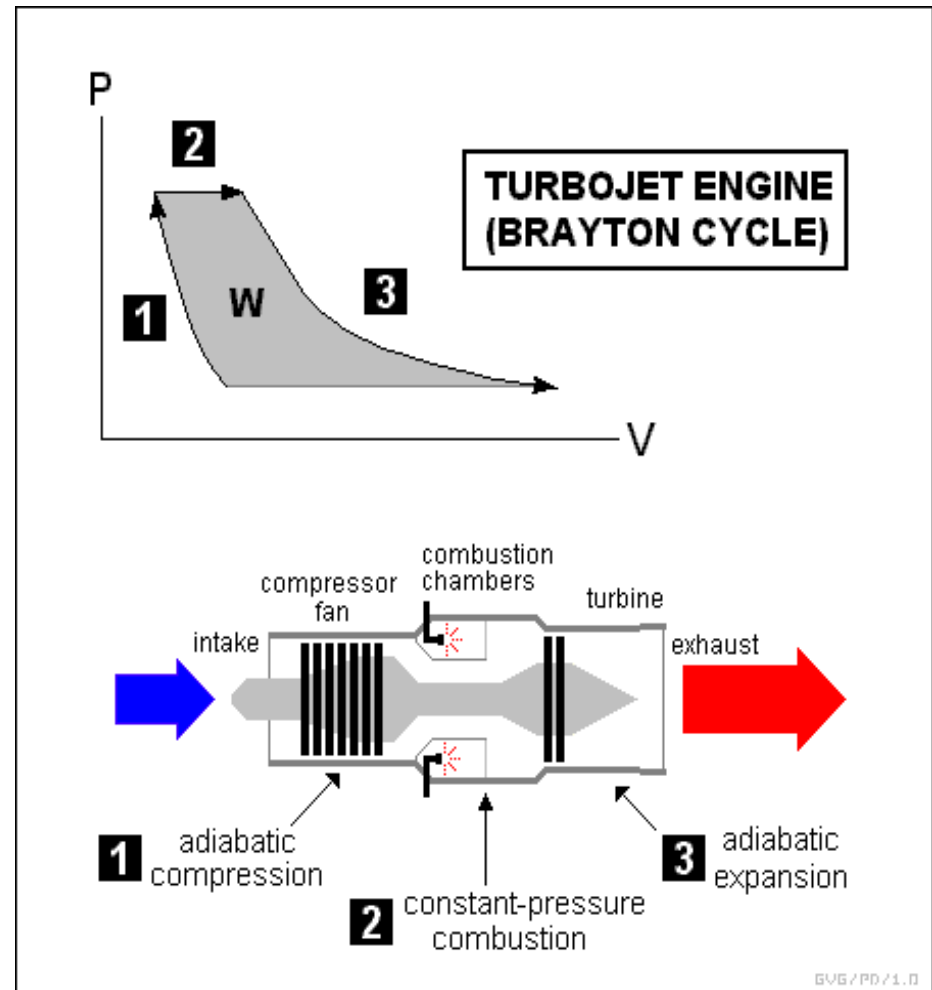
- **Supersonic Combustion RamJet**
- Very similar to the RamJet
- Compresses air and keeps it at a supersonic speed
- Combustion occurs with the use of hydrogen instead of jet fuel
- Air's temperature and pressure drastically increase, accelerating the aircraft
- Scramjet only works once it has reached a speed of Mach 5
- Theoretical speeds range between Mach 12 to Mach 24 or hypersonic
- Fastest recorded speed is Mach 9.6 by NASA's X-43A

# Scramjet: Diagram



# The Brayton Cycle

- 1) **Velocity decreases as air is compressed**
- 2) **Pressure is constant in combustion chamber**
- 3) **Pressure decreases and velocity increases as exhaust is expelled from the nozzle**





# Summary

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## ■ Key Facts

- Turboprop used in subsonic flight
- Turbofan is used largely in commercial aircraft
- Turbojet is the original jet, turbofans have taken the turbojets place for efficiency
- Ramjets work best in Mach 2-4, and do not function below 600mph
- Scramjets are not widely used and can travel at hypersonic speeds





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# Acknowledgements

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End.