Introduction to Mechanical Engineering

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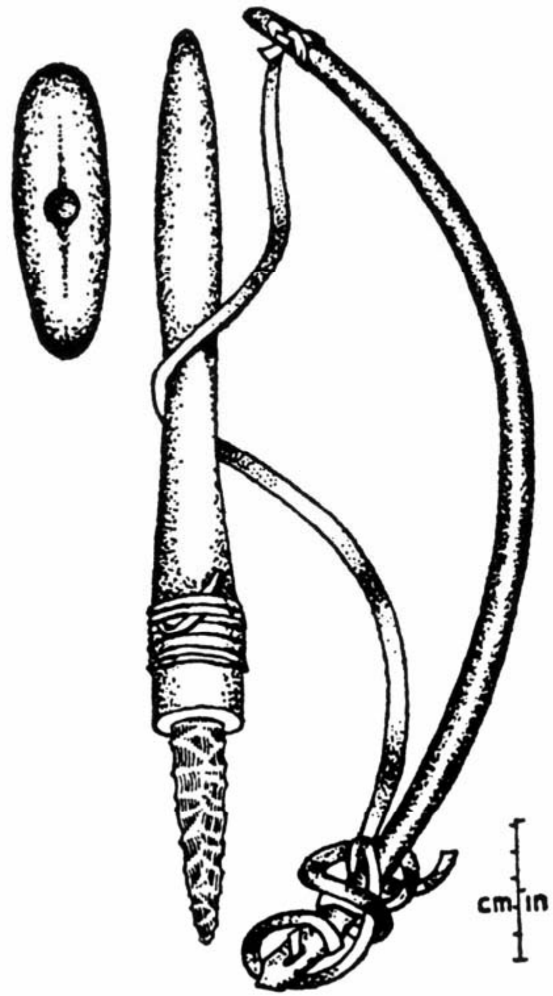
PREMA
PRECISION ENGINEERING & MANUFACTURING

Stone Age

Manufacturing:
- Manus (Lat.- Hand)
- Factus (Lat.- Made)

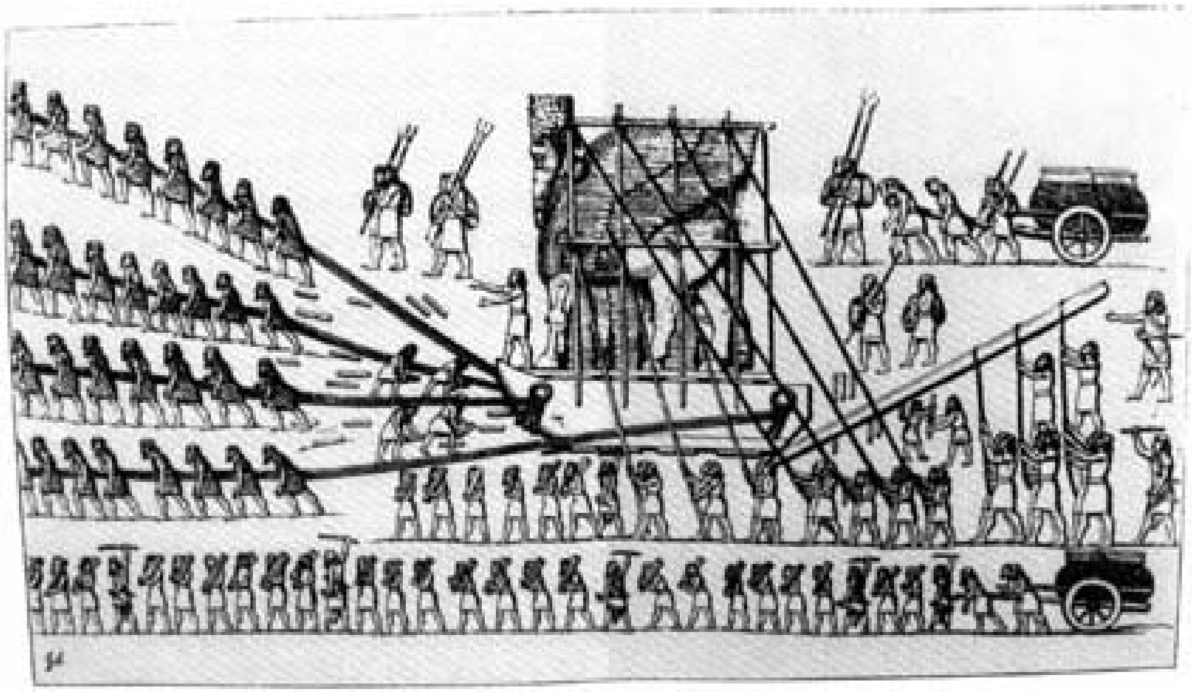
Old Stone Age:
- 500,000 B.C.
- Tools
- Agriculture, Cattle Raising
- Bow, Arrow (20,000 B.C.)

New Stone Age:
- 15,000 B.C.
- Pottery, Lever, Bow Drill



Bronze and Iron Age

Gold, Copper:
  5,000 B.C.
  Wheel, Bearing
  Lever Balance



Bronze Age:
    3,000 B.C.
    Writing

Iron Age (周):
  1,200 B.C.,
  Pulley, Crank Handle,
  Piston, Bellow, Wood Lathe

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Greek and Roman Period

Greek and Roman Period
(春秋戰國, 秦, 漢, 三國)

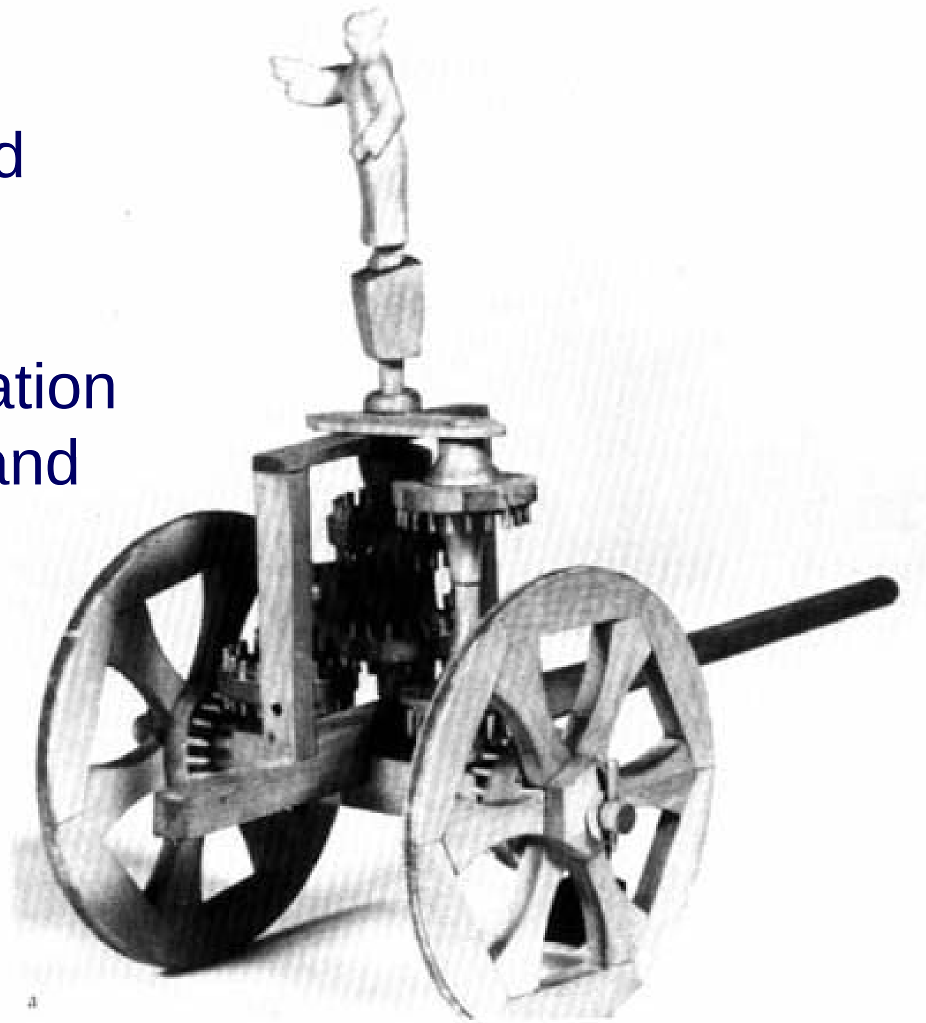
600 B.C. - A.D. 400

Inventions, Implementation

Animal power for mill and water pump

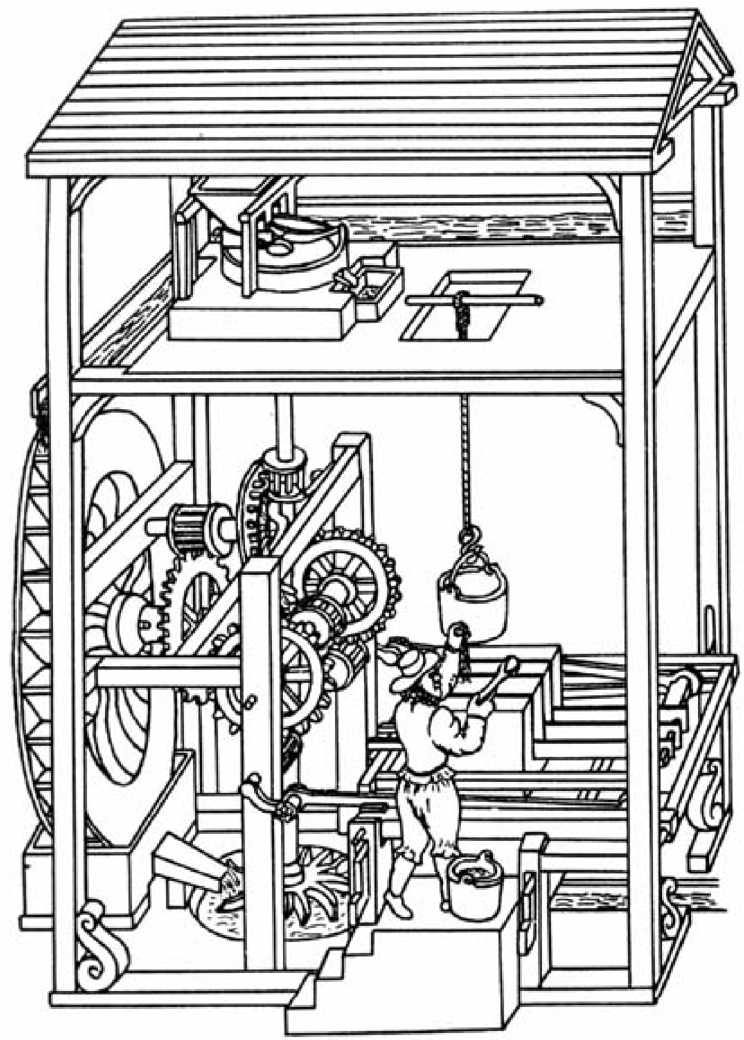
Wind and water wheel

Archimedes

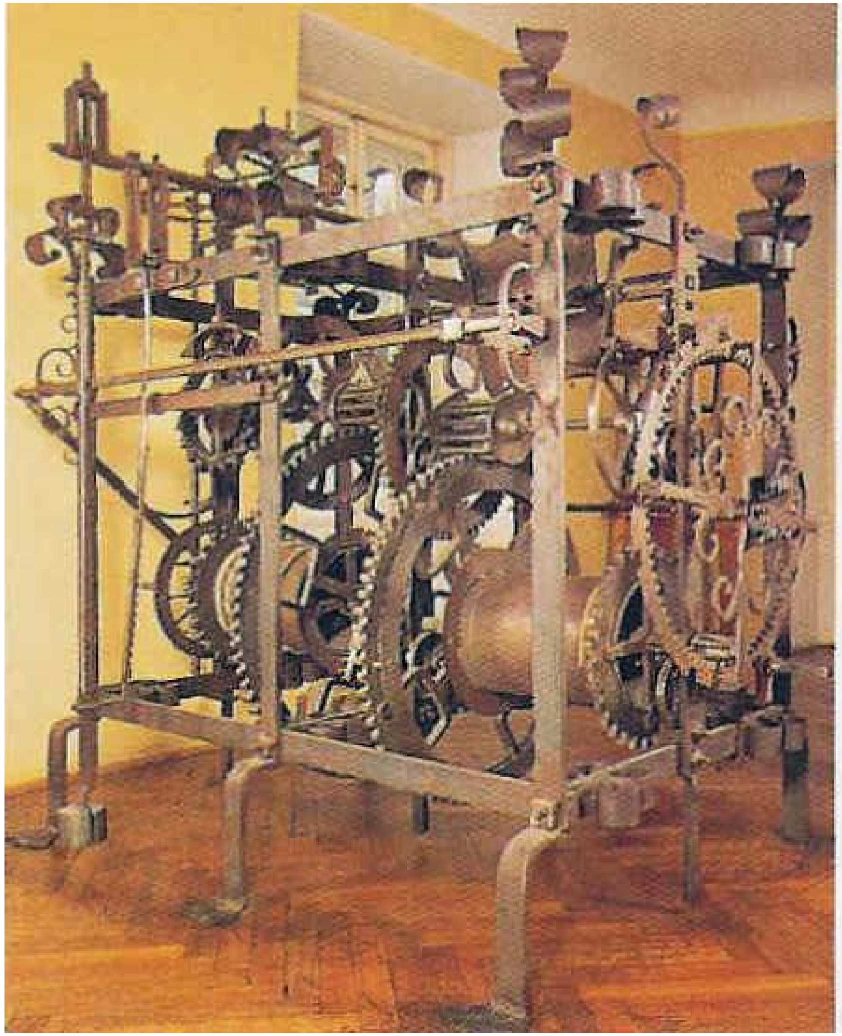


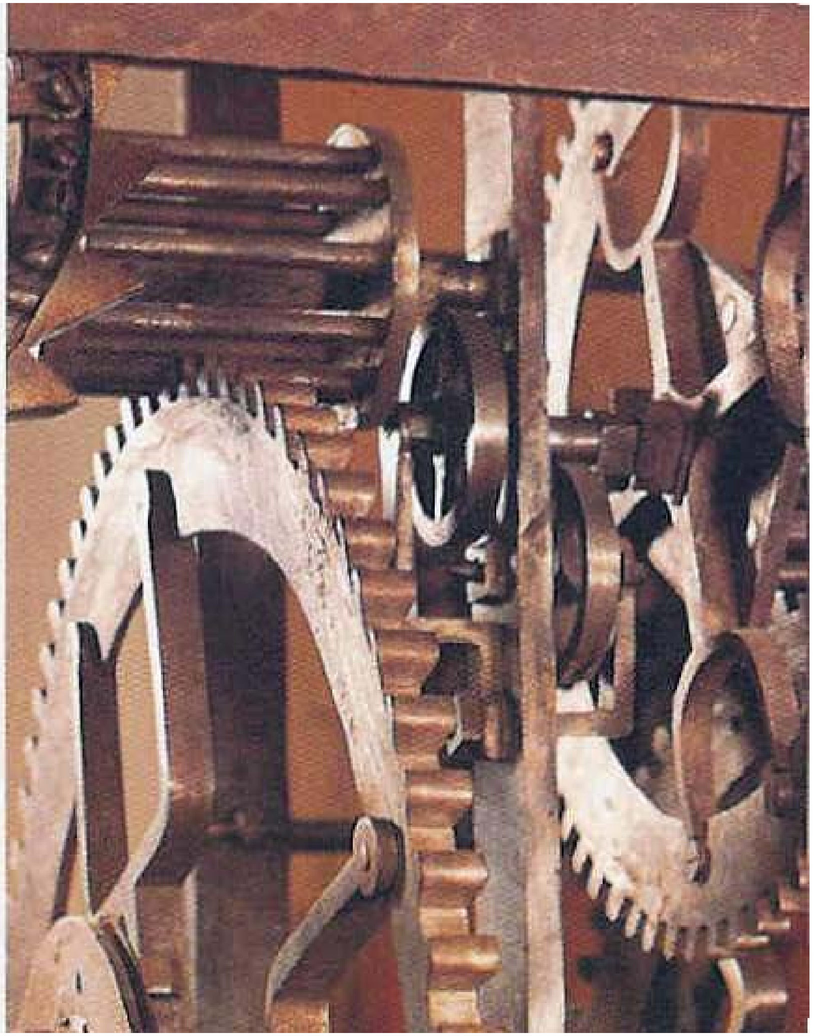
Dark Age and Renaissance

Dark Age and Renaissance
(隨, 唐, 宋, 元, 明)
A.D. 400 - A.D. 1500
Crankshaft and connecting rod
Casting of large bells and cannons
Mechanical clock
Metal machining
University



Mechanical Clocks





Before Industrial Revolution

Before Industrial Revolution
(明, 淸)
A.D. 1500 - A.D. 1750
Metal machining tools

Newcomen's atmospheric steam engine
1712, 6 hp, 1 cycle in 6 seconds
0.5 % Efficiency

Scientific revolution:
Galileo, Newton, Hooke, Boyle,
Pascal, Bernoulli

Industrial Revolution

Industrial Revolution: A.D. 1750 - A.D. 1850

Steam engine: 1776, James Watt

Mill, Pump -> Mine, Textile Factory

Ship and Train

Steel production in UK
  20,000 ton in 1750 to 2,500,000 ton in 1850

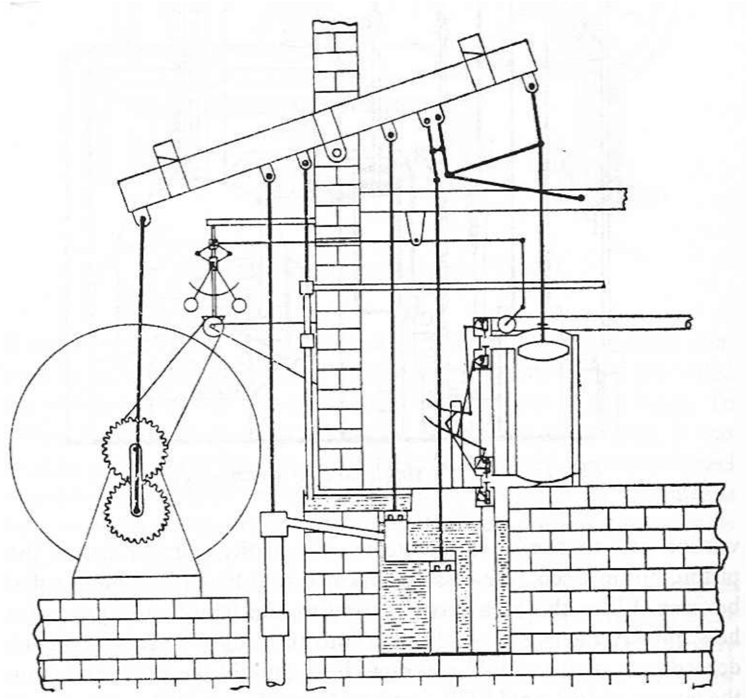
Machine Tools

Industrial Revolution

Steam Engine
1776, James Watt

2.7 % Efficiency

1832, Cornish: 17 %
(Automobile: 20 - 35 %,
Diesel: 30 - 45 %)



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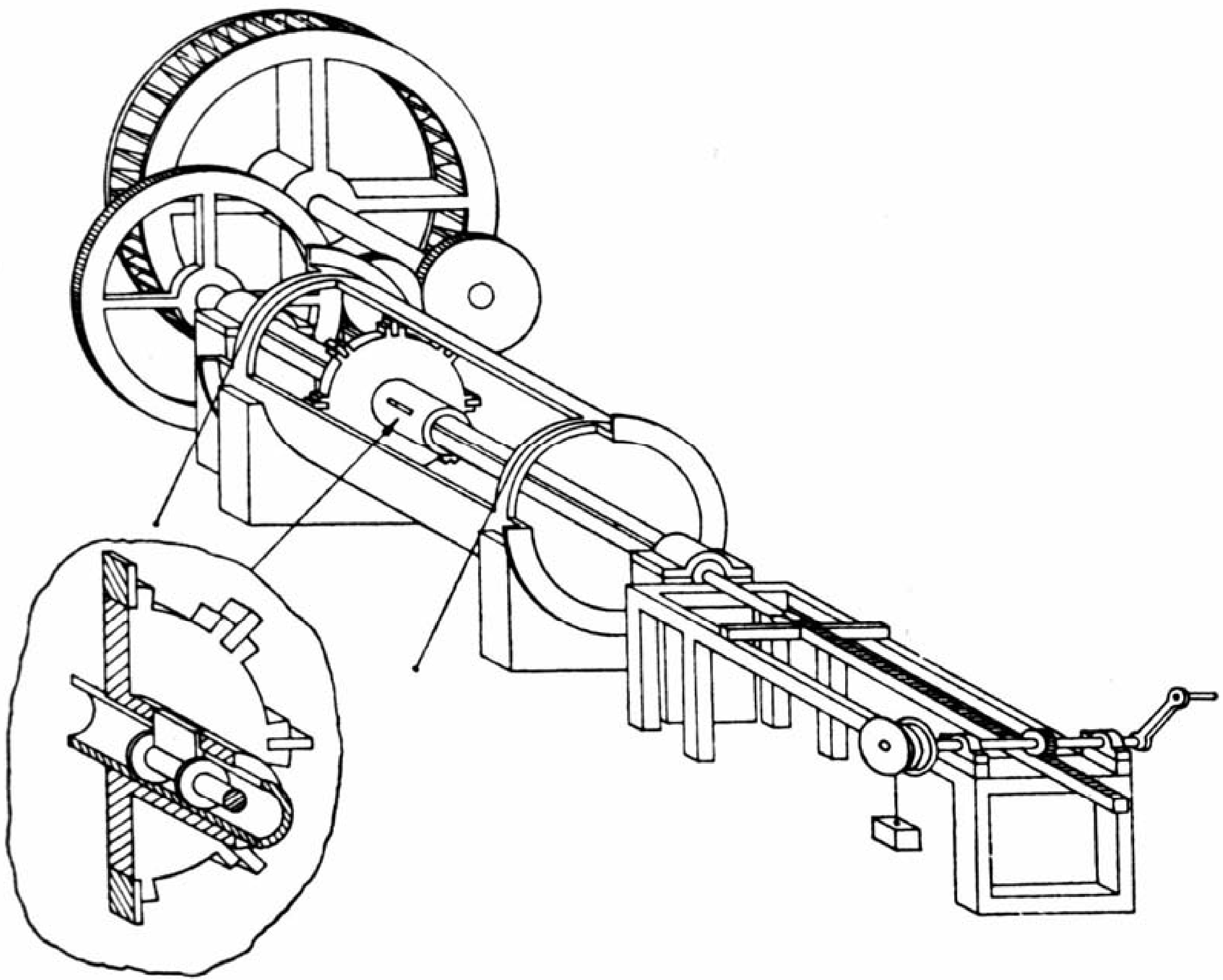
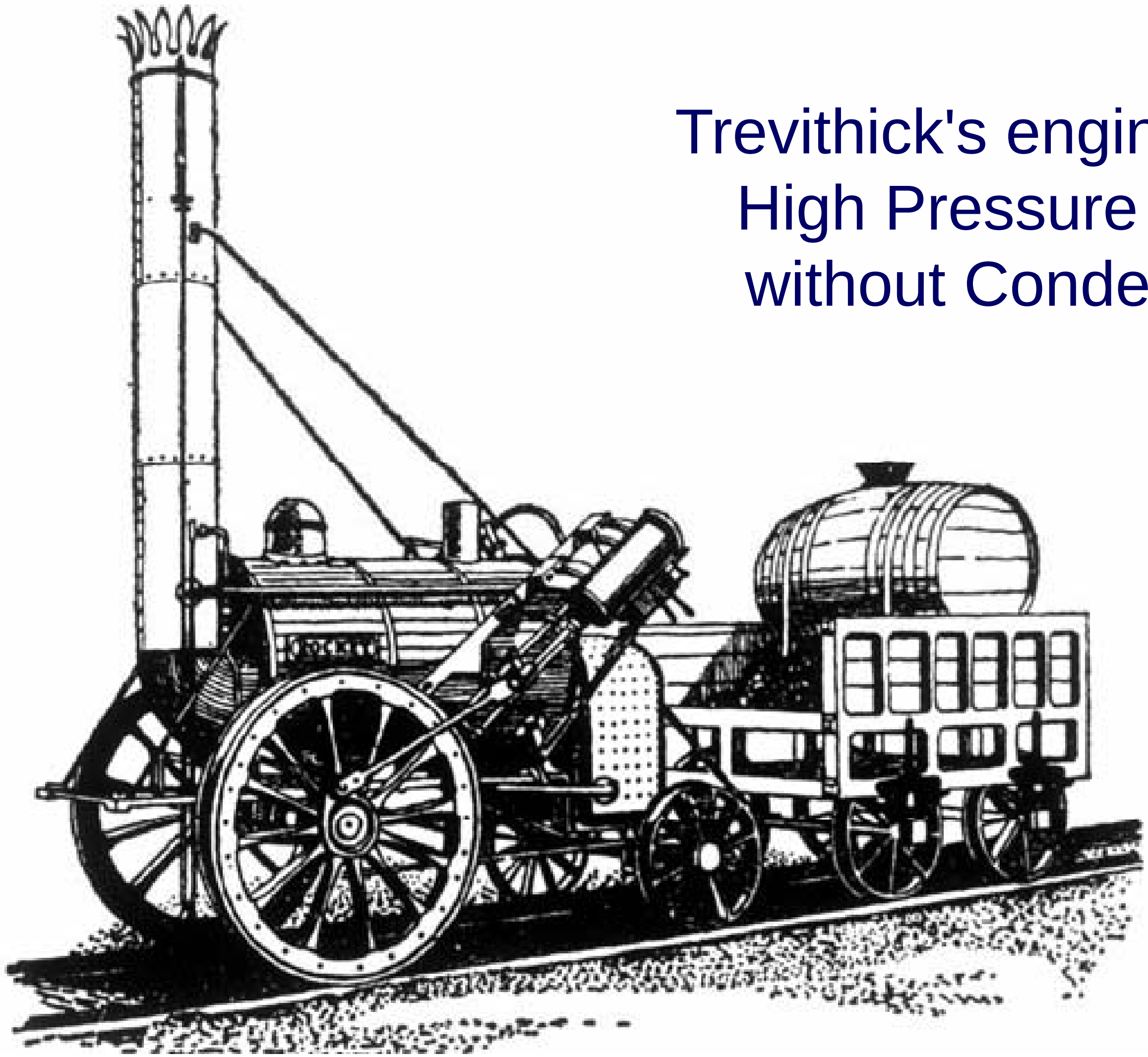
Wilkinson's Boring Machine



Rocket



Trevithick's engine: 1801
High Pressure Engine
without Condenser

Industrial Revolution

Thermodynamics: Property of Steam

Structural mechanics: Bridge

Interchangeable Parts of Muskets: 1801, Eli Whitney
   10,000 ordered in 1798
   500 delivered in 1801

Mechanization:1850

After Industrial Revolution

After Industrial Revolution: 1,850 AD - 1950 AD

Bicycle

Automobile

Edison, 1882

Electric Power Plant in NY City

M/C Independently Powered

Frederick Taylor: Tool Life and H.S.S Tool

50,000 experiments, 80,000lbs of chip

Hard automation:1920

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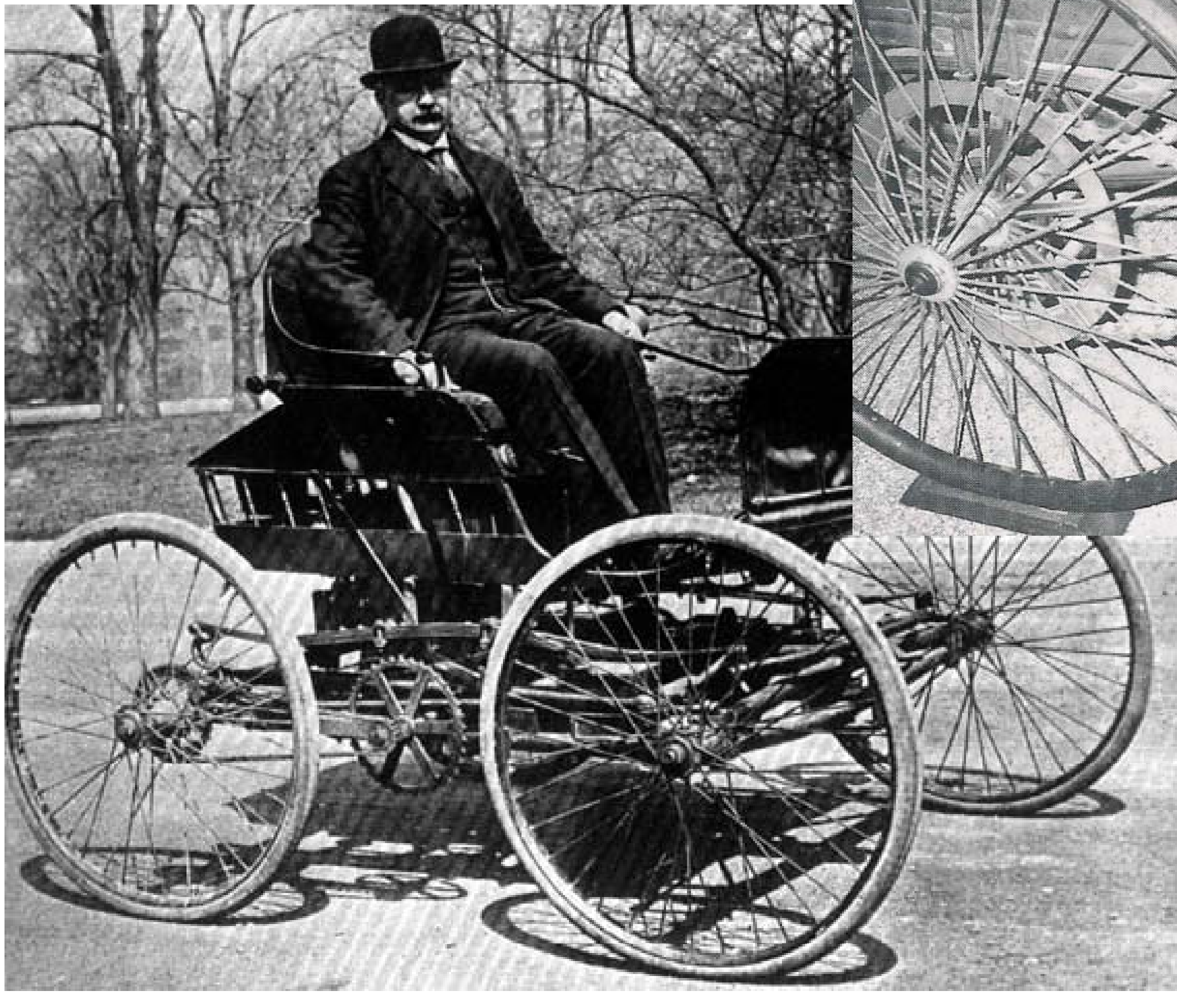
Bicycles in Early 1800's

Bicycle: From the 17th Century
Steerable bicycle: 1817
Front Wheel drive: 1850
Rear Wheel drive: 1878

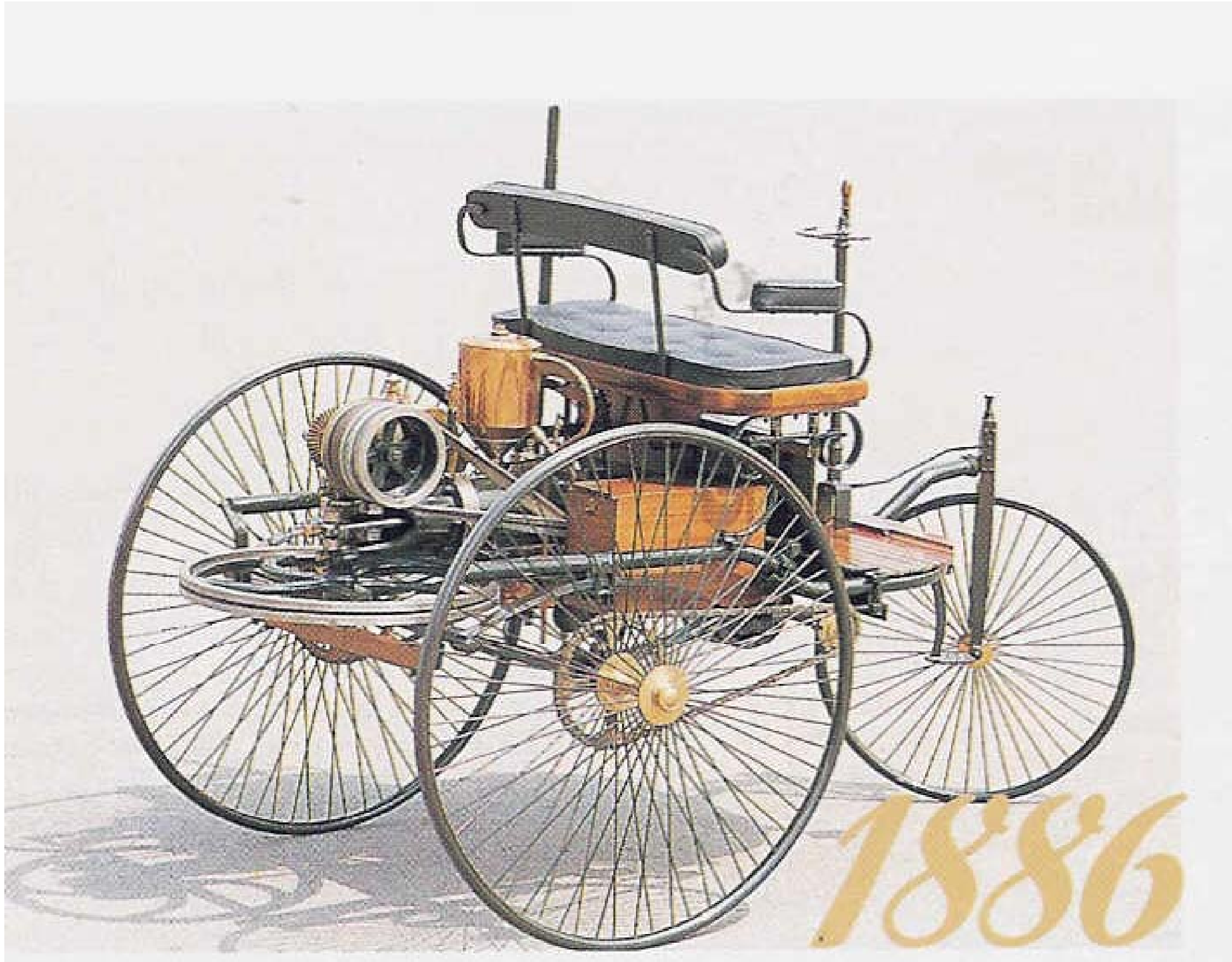
Horseless Carriage



Automobile

1860, Renoir: Explosion at Both Ends of the Cylinder
1872, Brayton: 2 Cycle Internal Combustion Engine
1876, Otto:4 Cycle Engine
1886, Benz: Commercial Automobile
1887, Daimler: Carburetor, Electric Spark Plug,
320 kg, 1.5 hp, 600 rpm
1890: Concept of Modern Automobile
Chassis, Steering Wheel, Braking System
1908, Ford: Model T, 4 Cycle, 20 hp,
Conveyor Line, Division of Labor, Mass Production
Price Reduction: $2000 -> $350
1908-1927: 15 million cars sold
50% of US Market

First Commercial Benz



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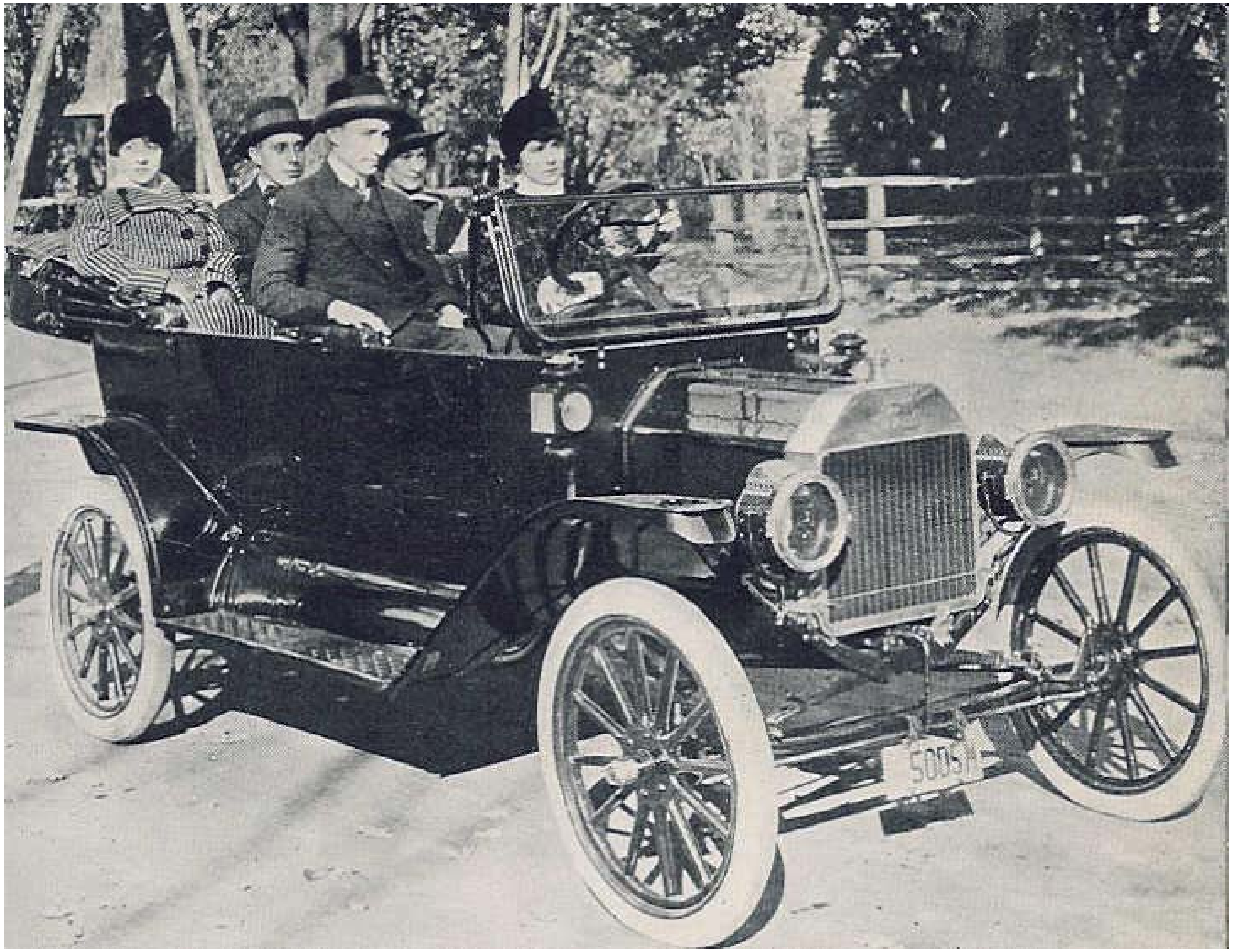
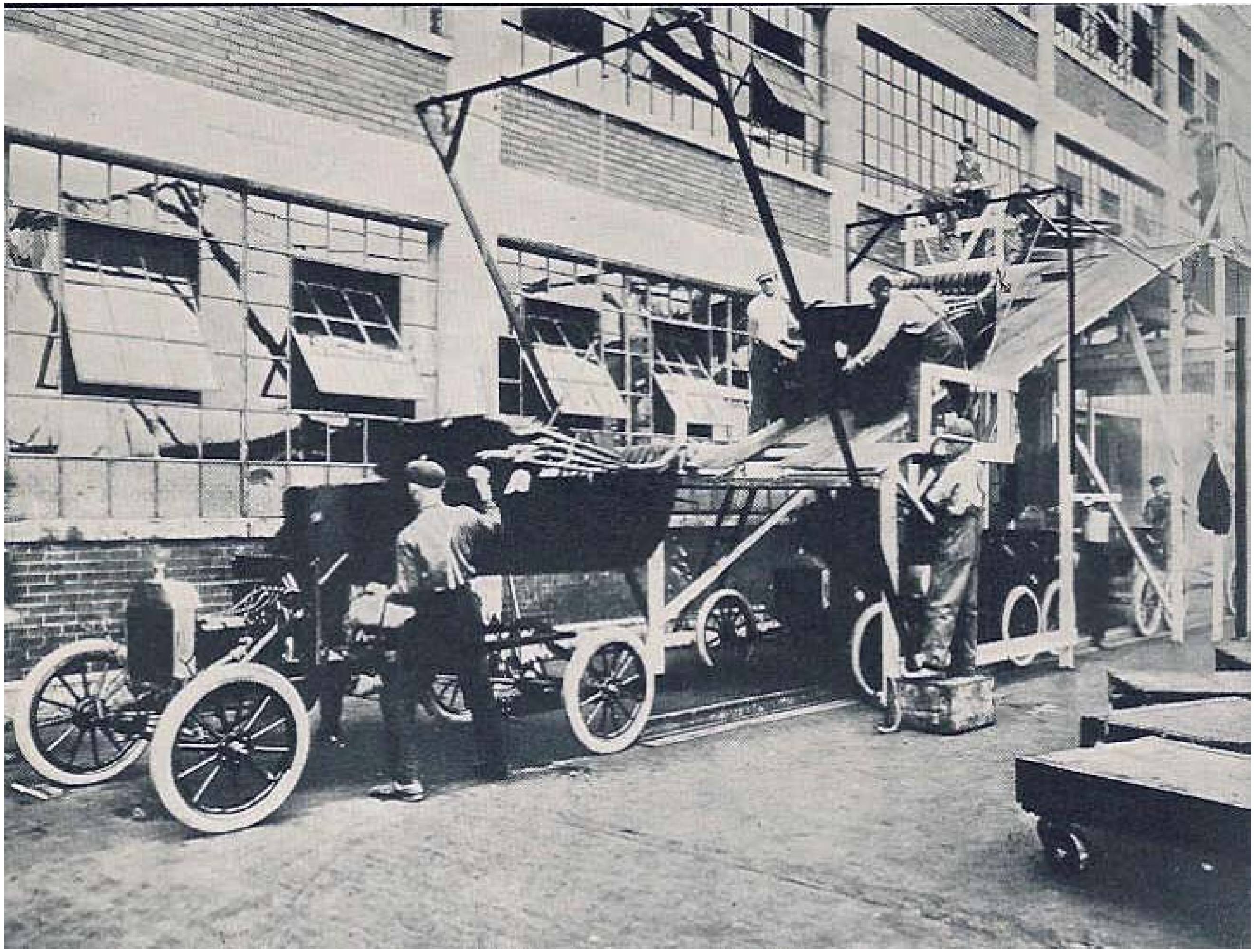
Ford Model T

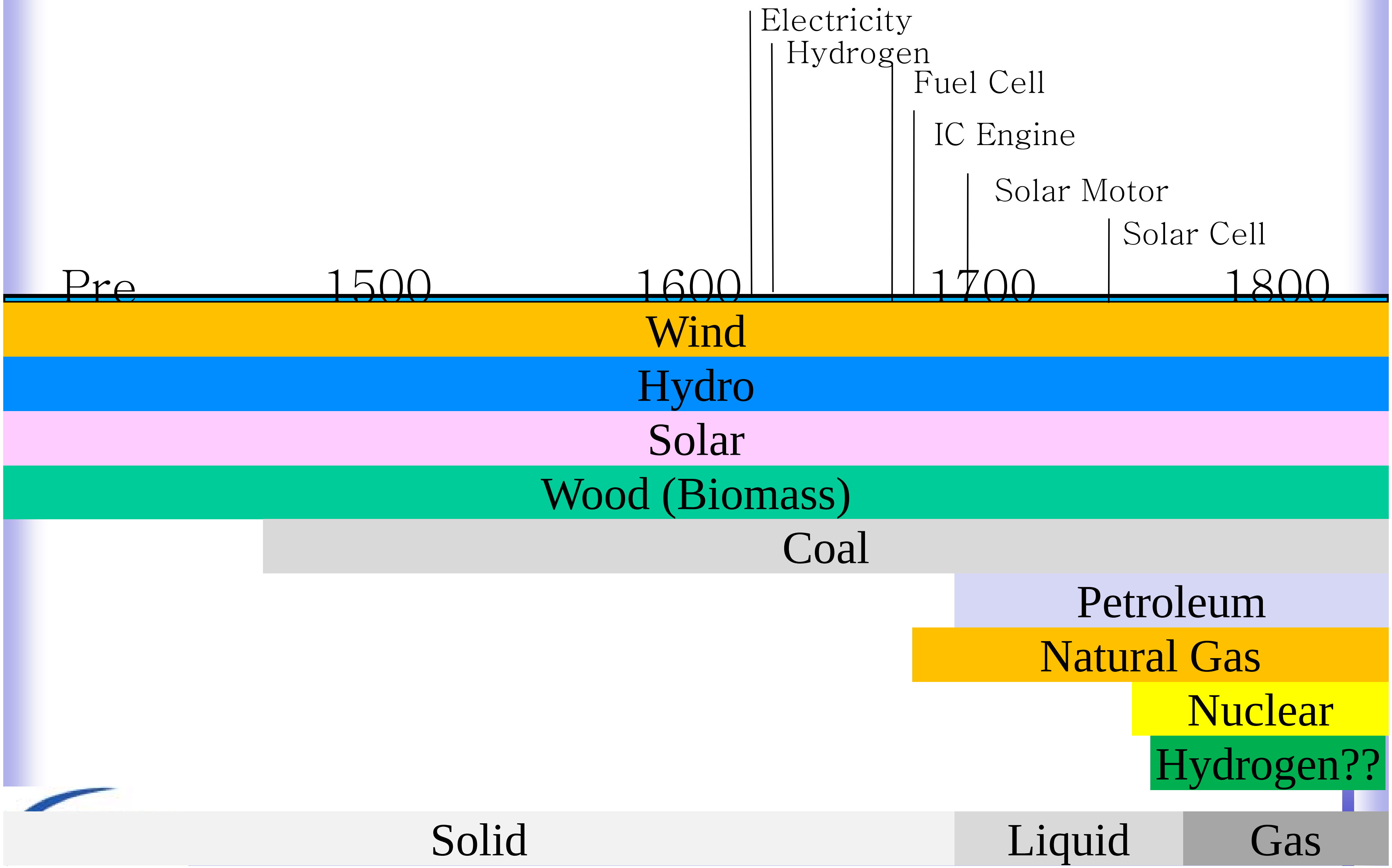


Model T Assembly Line



What is This?

History of Energy



2^{nd} Industrial Revolution

1950's: Computer
NC (Numerically Controlled) Machine

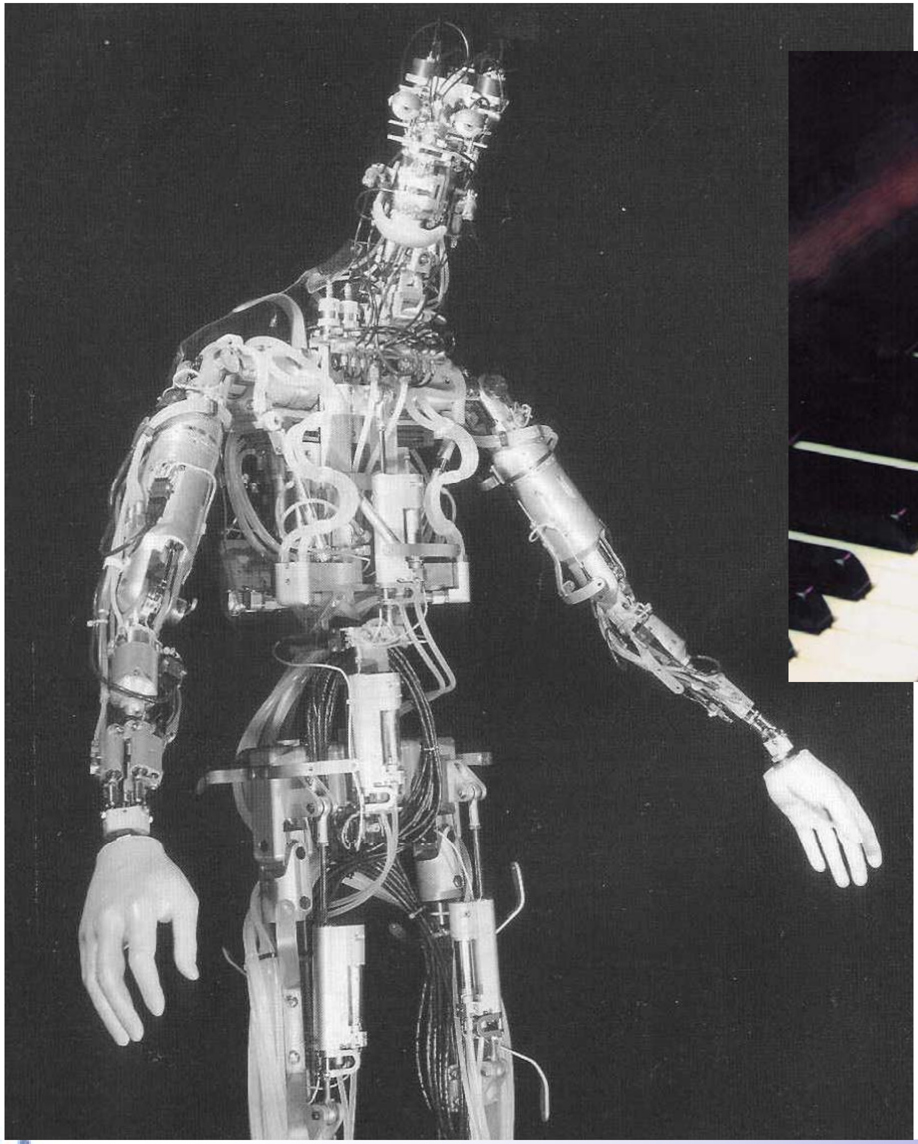
1960's: Robot

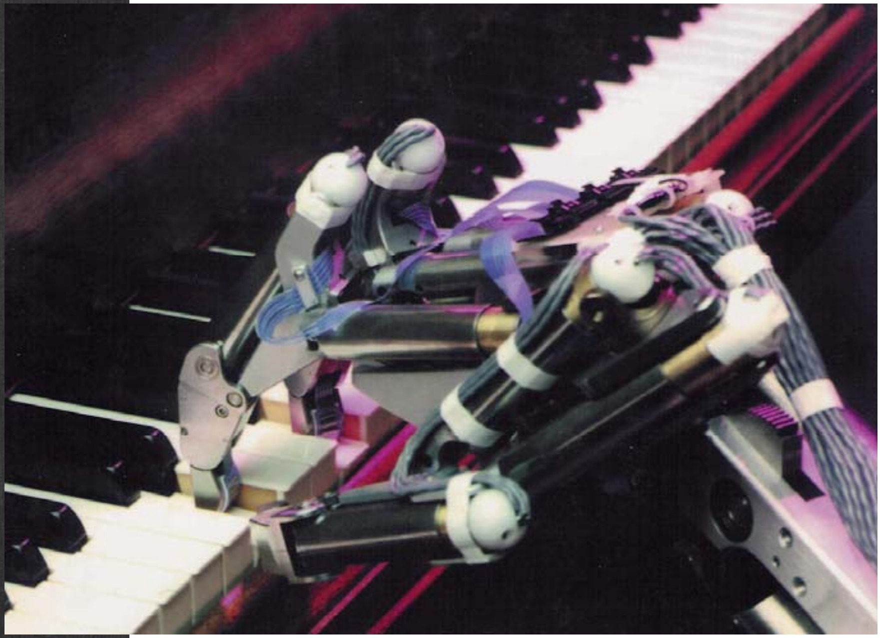
1970's: CAD (Computer Aided Design)
CAM (Computer Aided Manufacturing)
CAE (Computer Aided Engineering)

1980's: FMS (Flexible Manufacturing System)
CIM (Computer Integrated Manufacturing)

1990's: IMS (Intelligent Manufacturing System)

Human Robots





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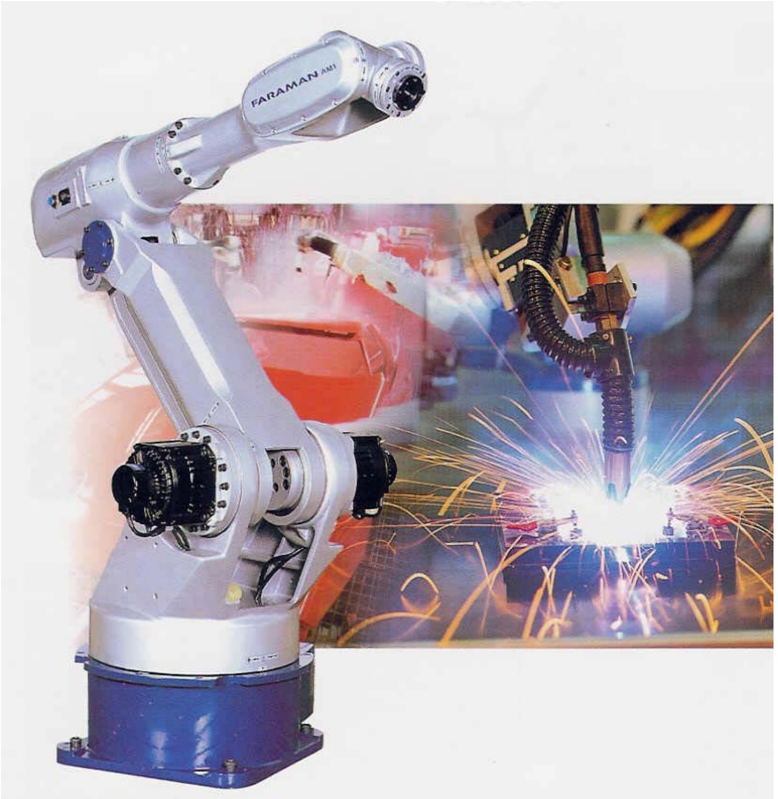
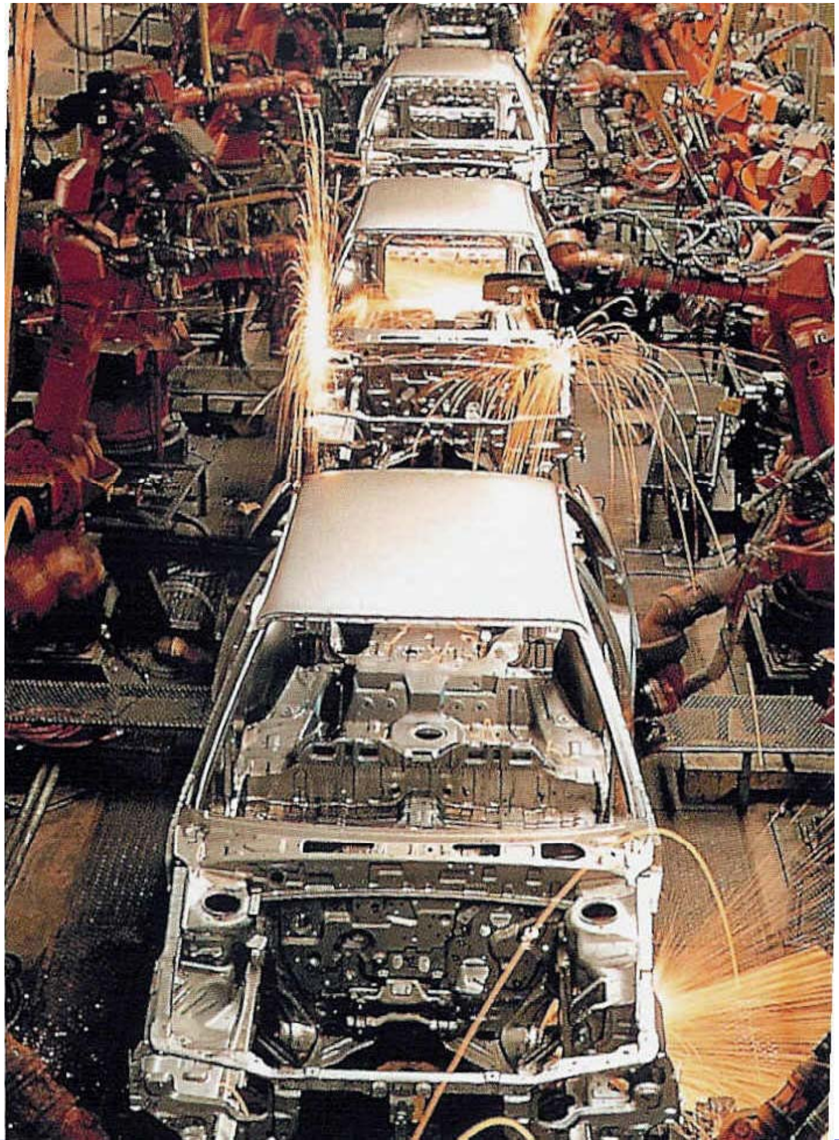
Industrial Robots



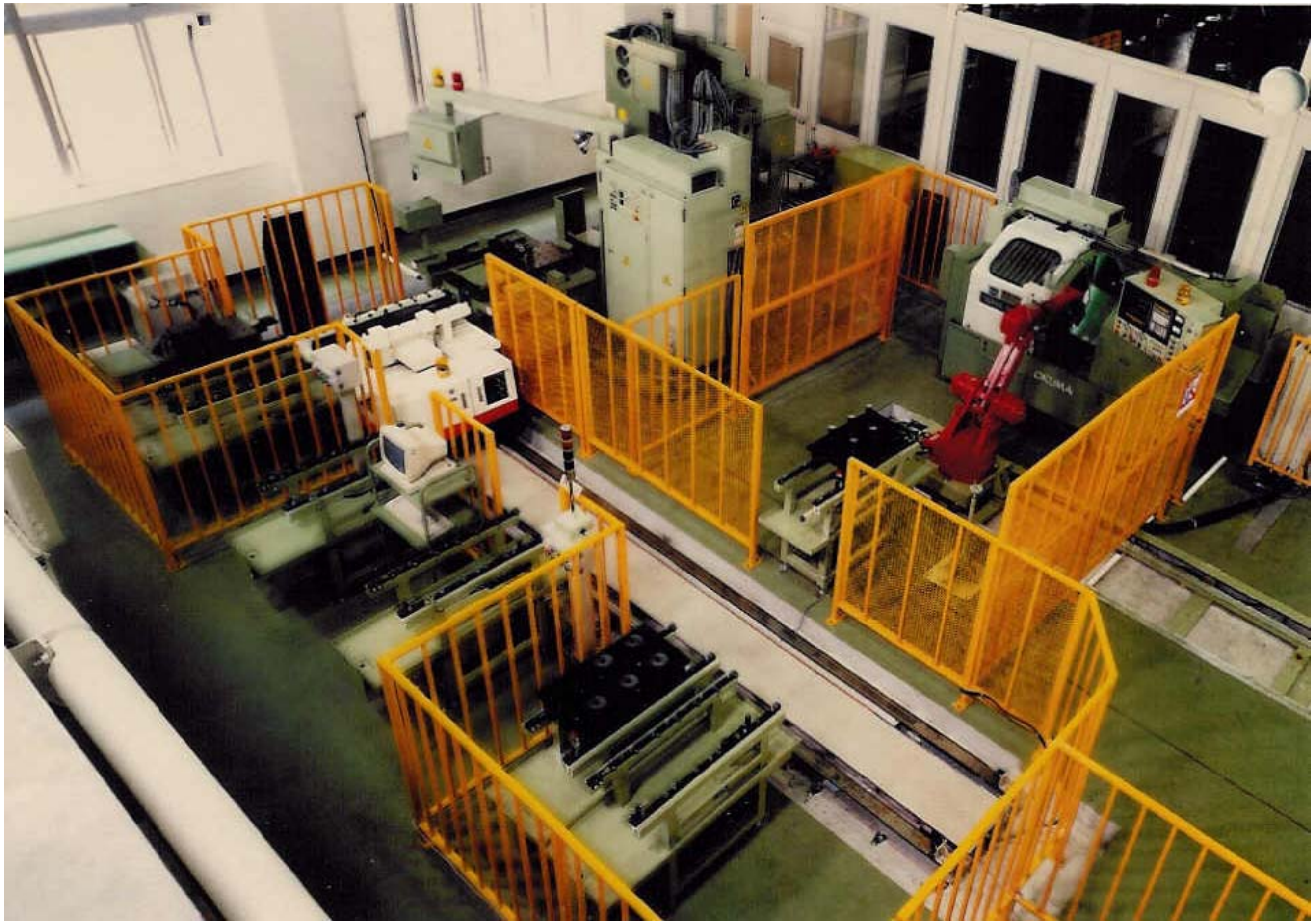
Auto Body Assembly

Avante XD Spot Welding

Number of Panel: 167
Number of Welding Spot: 4849
Weight: 310 kg



Okuma FMS Cell



Makino FMS

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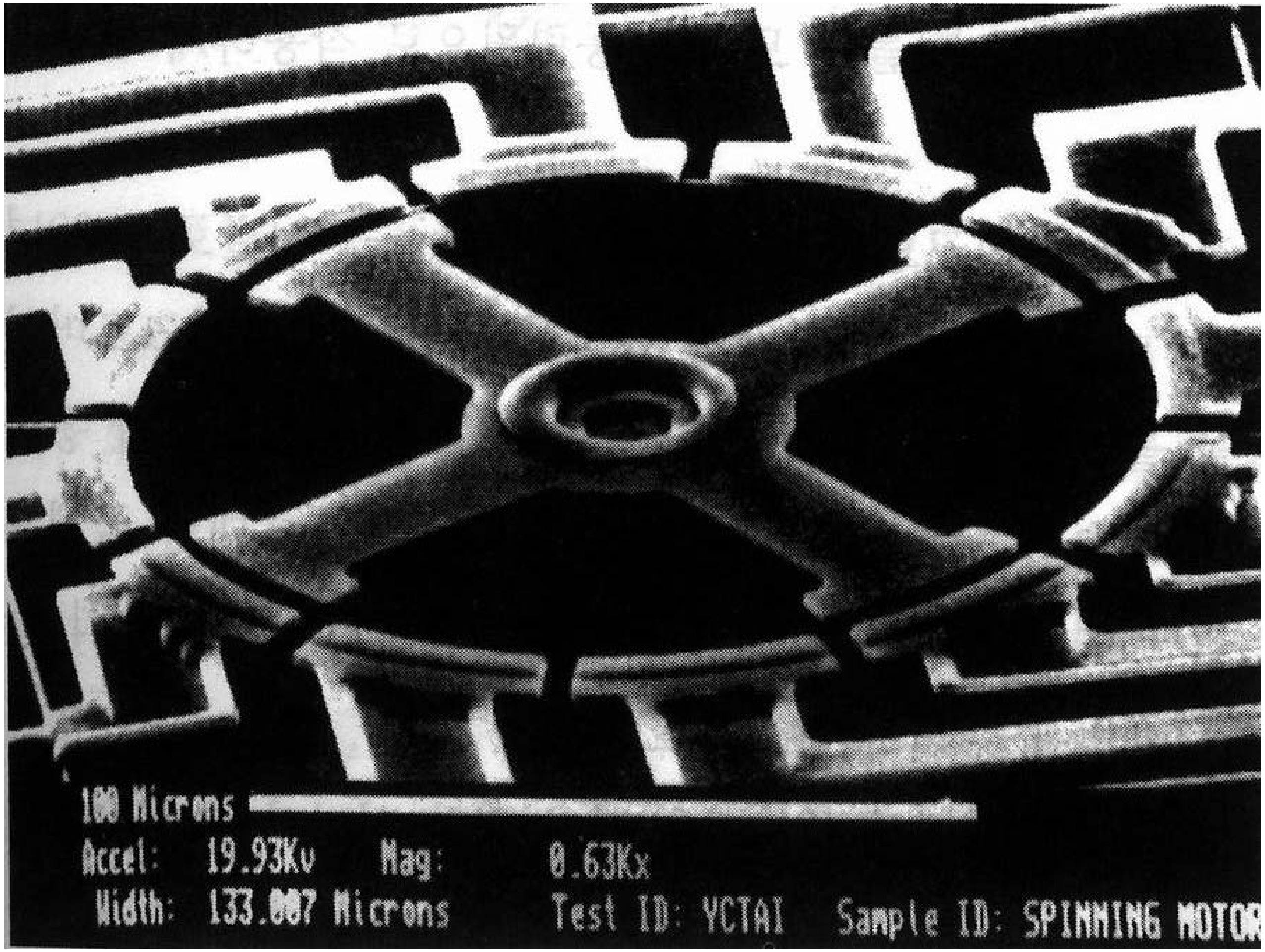
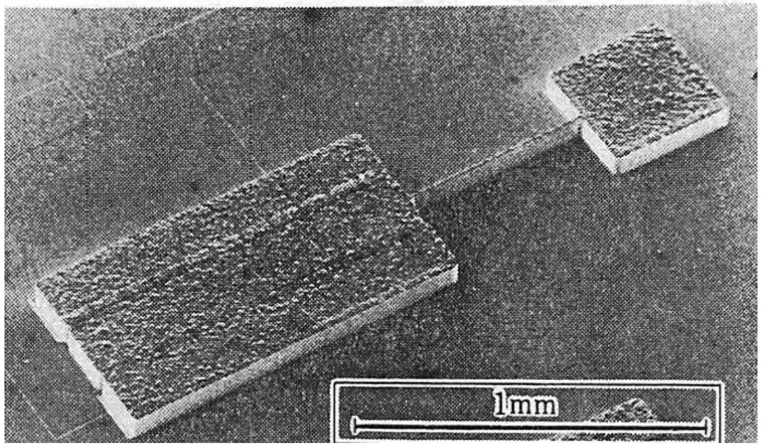
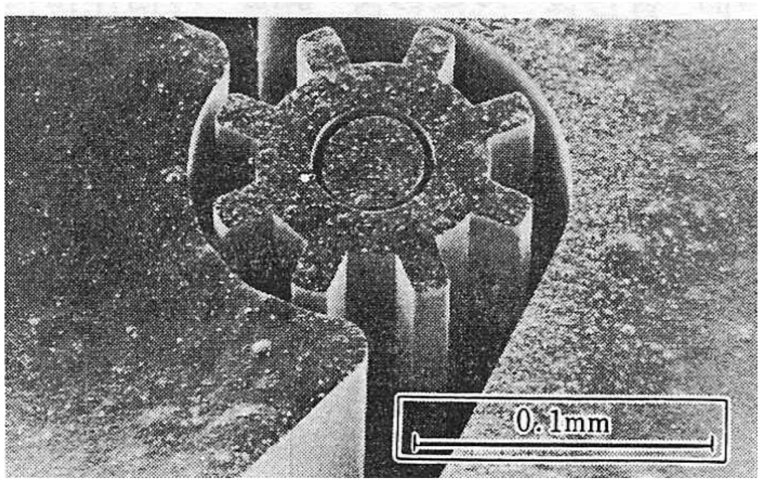
Silicon Micro-motor

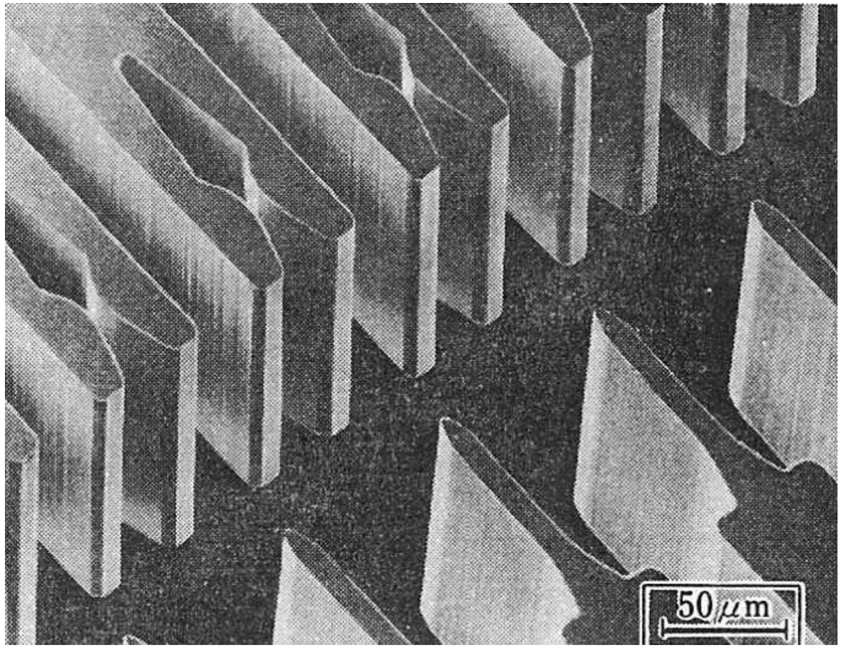


Why do we make a micro-crown?

LIGA Products



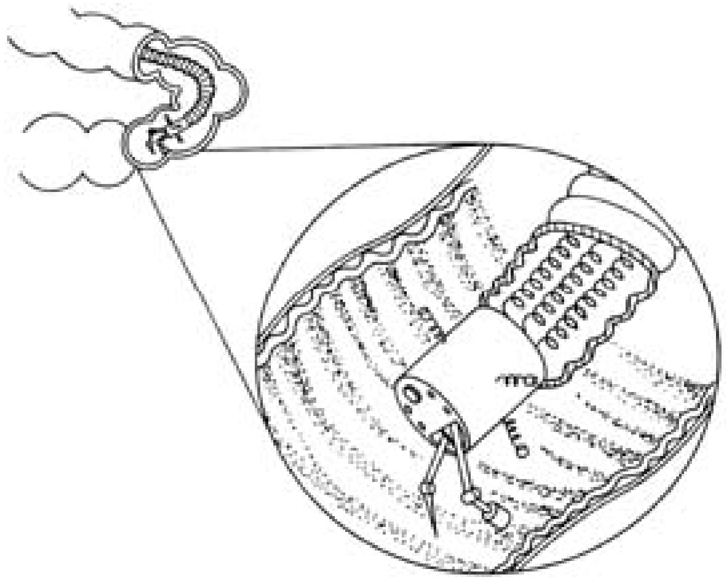




Micro-machines

High surface force
Very low Reynolds number
Energy transmission problem

Suitable for sensors or structures
A long way to go to make meaningful machines

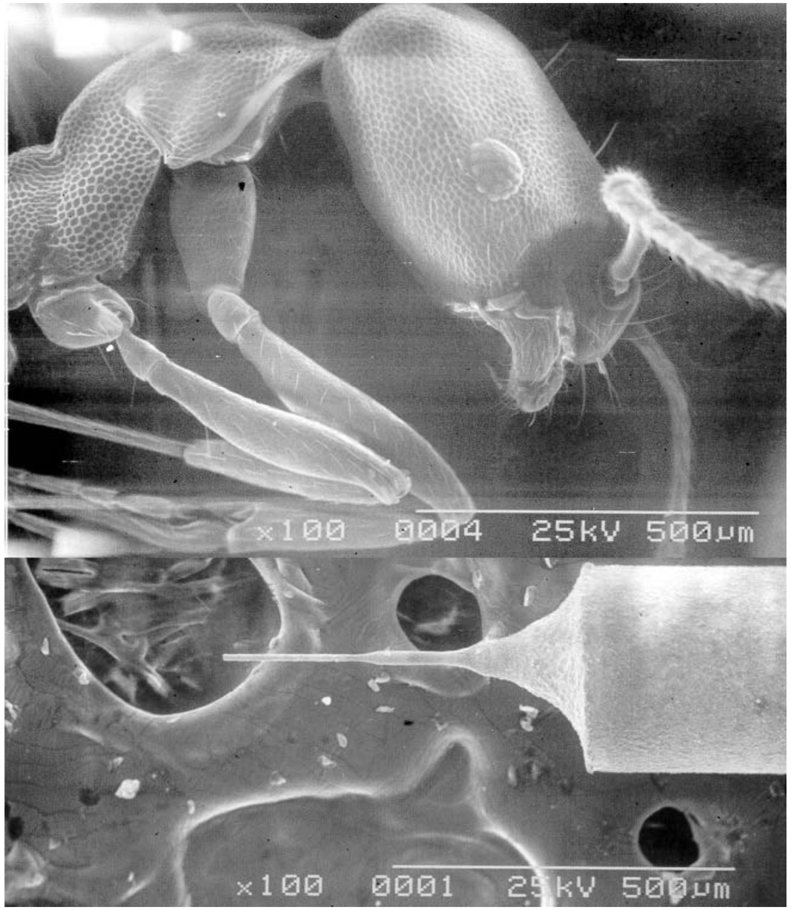


Micro-Catheter

Micro-catheter with
rotating ultrasonic sensor

Micro-catheter with shape
memory metal actuator

Micro-EDM



Diameter 6 μm
Length 300 μm
WC Alloy

Mechanical Engineering

A mechanism is an assembly of several mechanical elements which move according to the motion of driving element.

If the mechanism transmits substantial amount of force, it is called a machine.

Nail clipper, CD player, Vending machine

Mechanical engineering is a field of making a useful mechanism or machine by using various materials

Mechanical Engineering

Behavior of Materials

- Strength of Solid (Solid Mechanics)
- Movement of Fluid (Fluid Mechanics)
- Deformation of Gas (Thermodynamics)
- Transfer of Energy (Heat Transfer)

Design and Manufacturing

- Devising Machine (Kinematics and Design)
- Motion of Machine (Dynamics)
- Control of Machine (Control and Mechatronics)
- Manufacturing of Machine (Manufacturing)

Solid Mechanics

Calculation of strength of materials and machine.

Concept of force known about lever and lever balance from the stone age.

Strength of material for the bridge during Renaissance.

Structural mechanics for the steel bridge during industrial revolution.

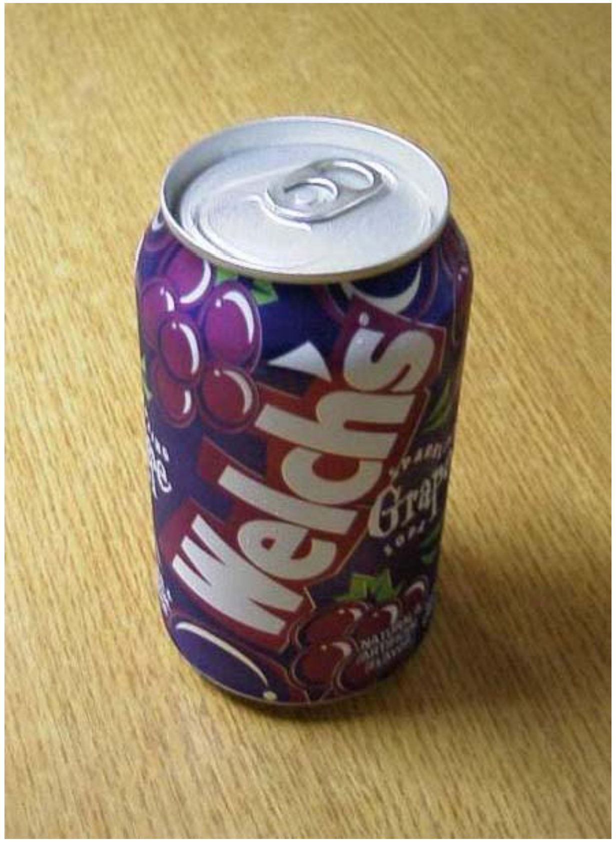
Soda Can

Car Crash

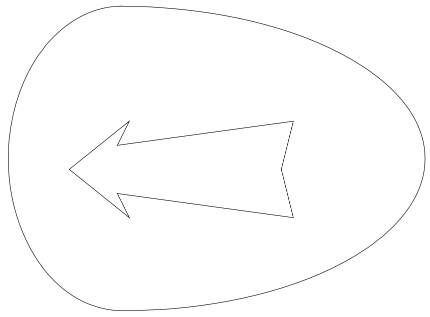
Collapse of Bridge and Building

Friction and Wear

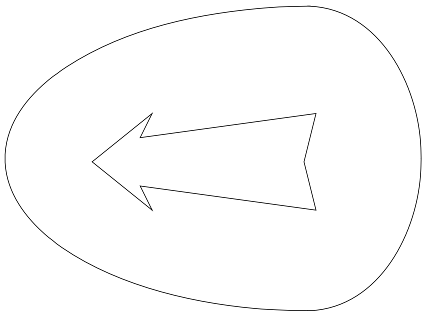
Engineering Principles of a Can



Which is faster?

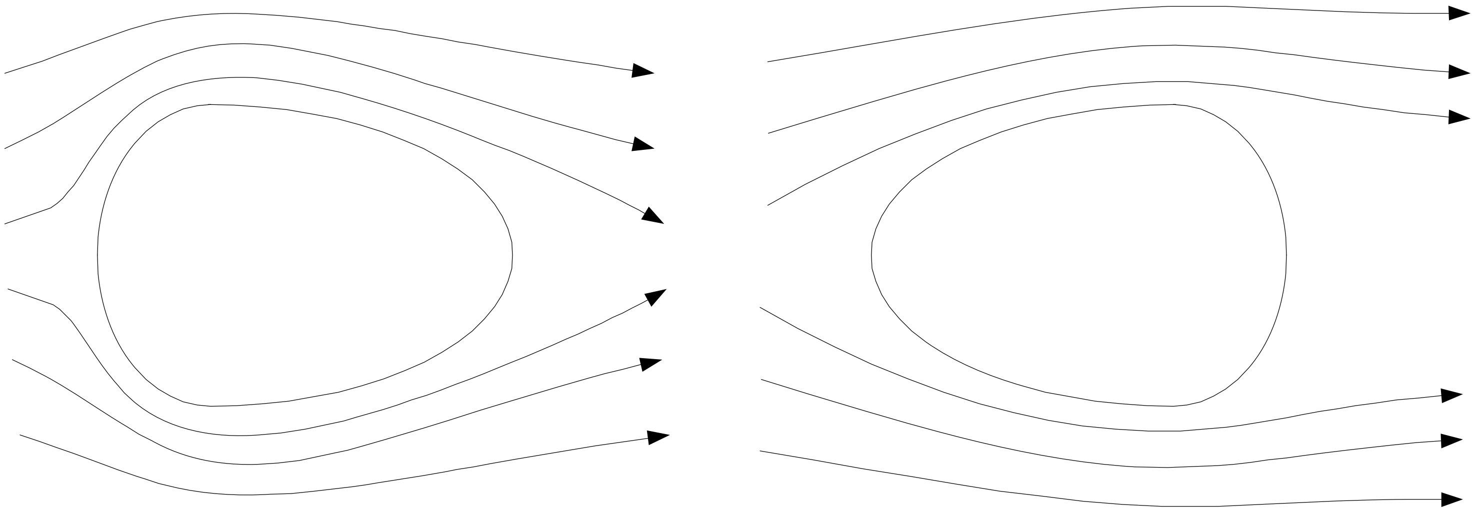


(A)

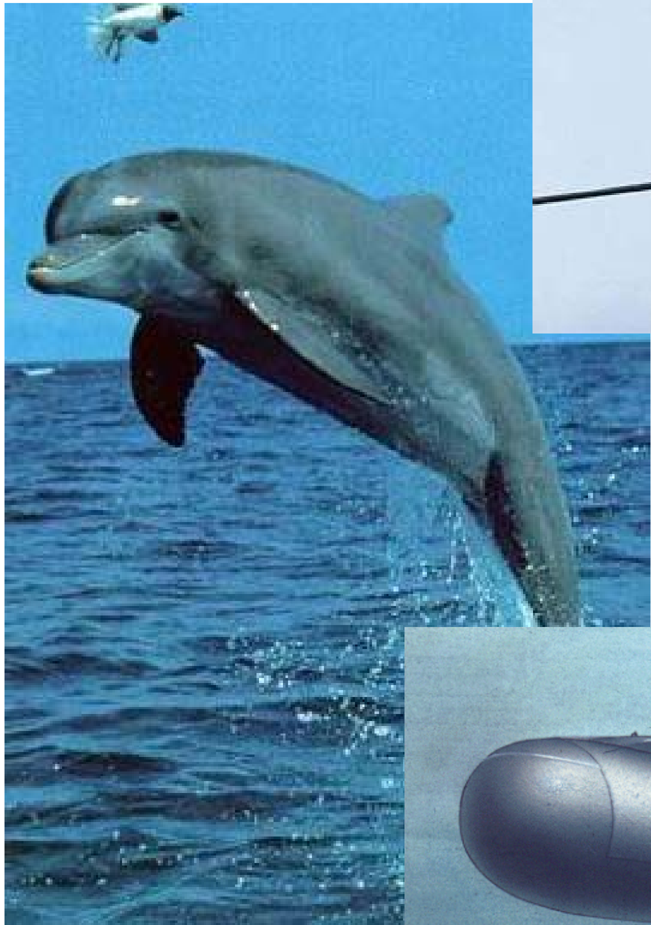


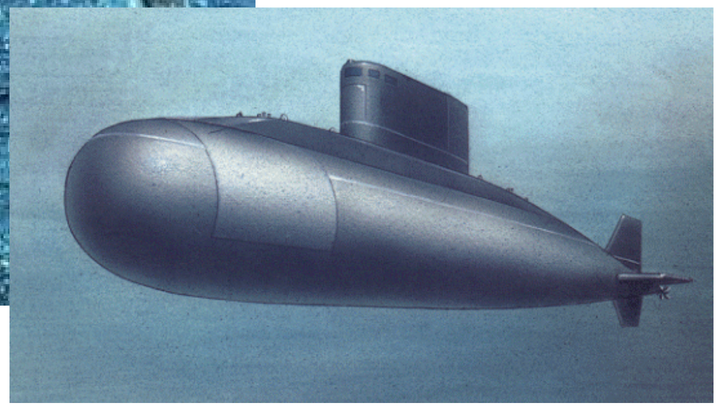
(B)

Which is faster?

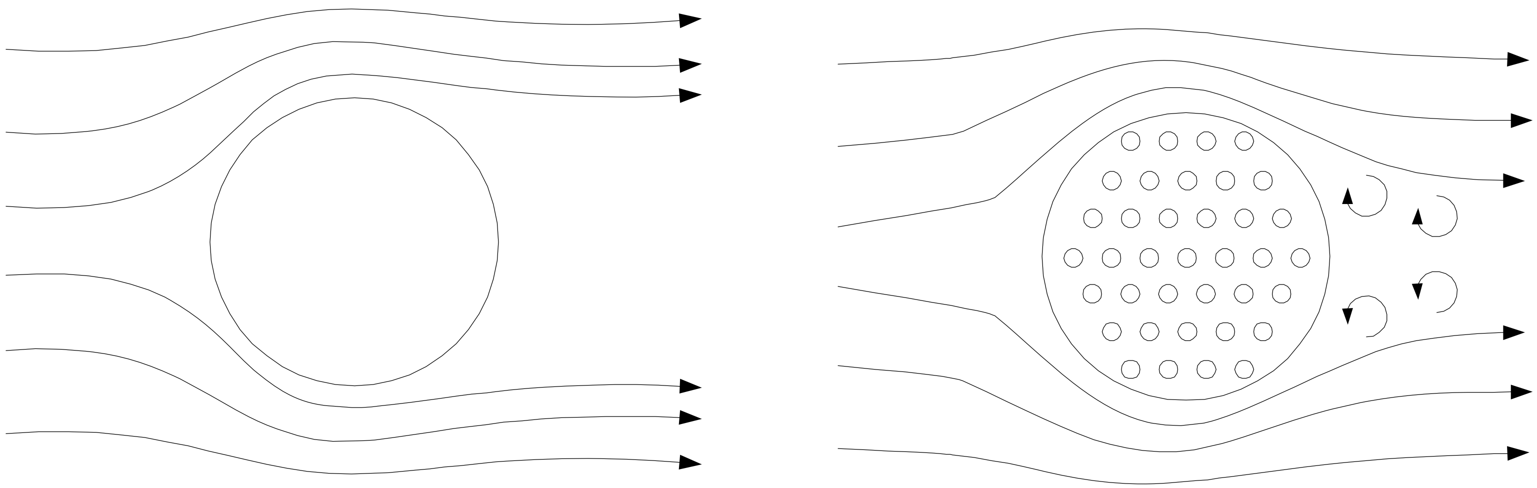


Which is faster?

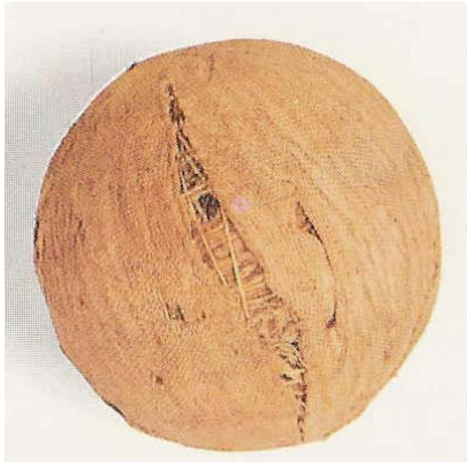




Which flies further?



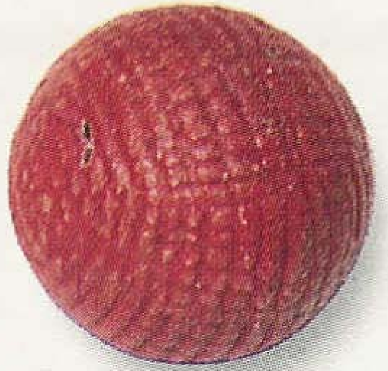
Feathery Ball



Last feathery made by Robertson, in 1852

Guttie Ball

Smooth ball made by
Robertson in 1852



Red, hand-hammered
guttie for use in snow

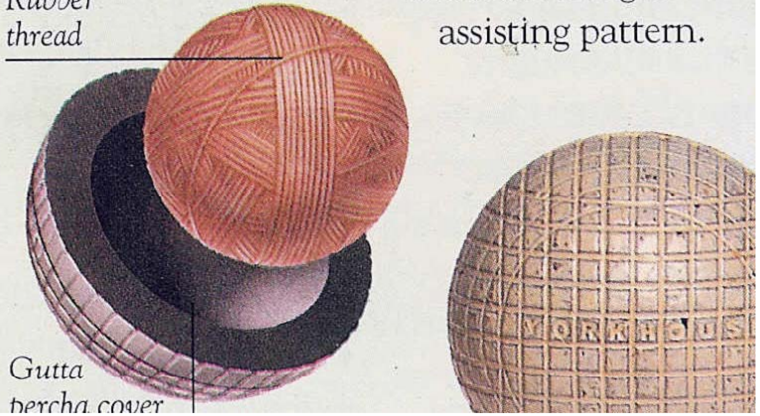
Hand-hammered
Robertson guttie from
the 1850s

Guttie ball stamped
with a distinctive
circle marking

Rubber-core Ball

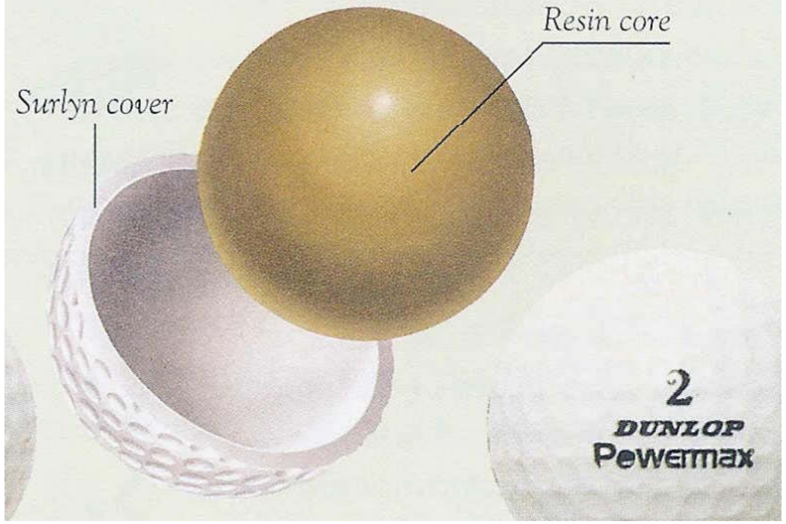
The Rubber-core Ball

The rubber-core ball, developed by Coburn Haskell in 1898 and first made commercially in 1901, could be hit farther and faster than previous designs. It was made by winding great lengths of rubber yarn, stretched under tension, around a rubber core. A livelier core enabled golfers to exercise more control over the ball's spin and flight. Early models had a gutta percha covering, on to which was moulded a flight-assisting pattern.



Two-piece

A high-energy acrylate or resin core with a tough cut-proof blended cover gives the two-piece more length than any other ball. It is also virtually indestructible which, with its top roll distance, makes it by far the most popular ball among ordinary golfers. However, because it has a lower spin rate, it is less easy to control.



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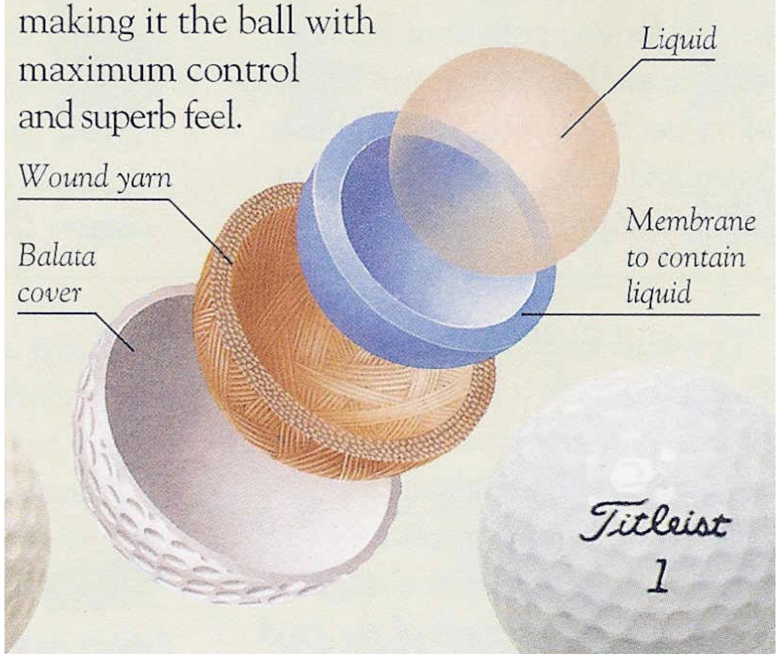
Rubber-core Ball

THREE-PIECE (SURLYN COVER)

This version of the three-piece wound ball has a solid rubber core over which rubber yarn is wound for good control. The cover is made from Surlyn, a thermoplastic resin that is harder than balata and is thus considerably more durable; it is virtually uncuttable.

THREE-PIECE (BALATA COVER)

The balata-covered, liquid-centred three-piece ball might be described as the most advanced of golf balls. The wound construction over a liquid centre, combined with a soft, synthetic balata cover, produces the highest spin rate, making it the ball with maximum control and superb feel.



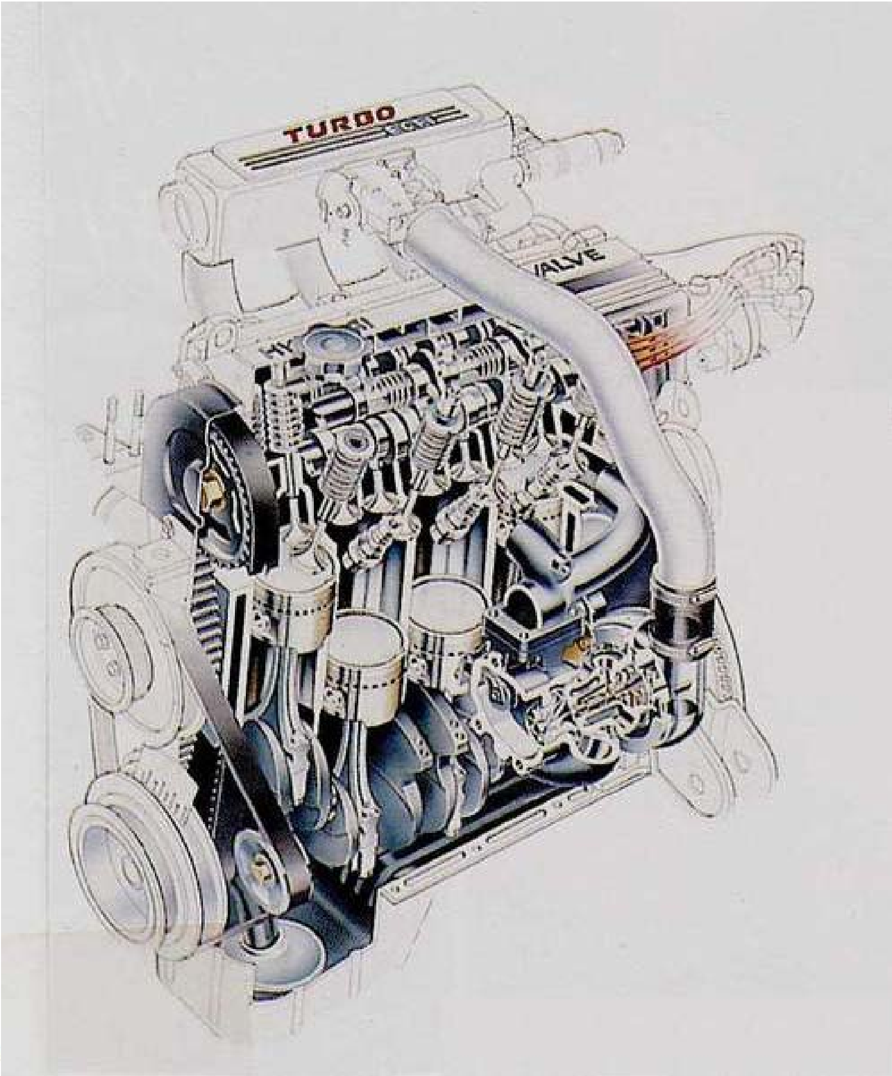
Fluid Mechanics

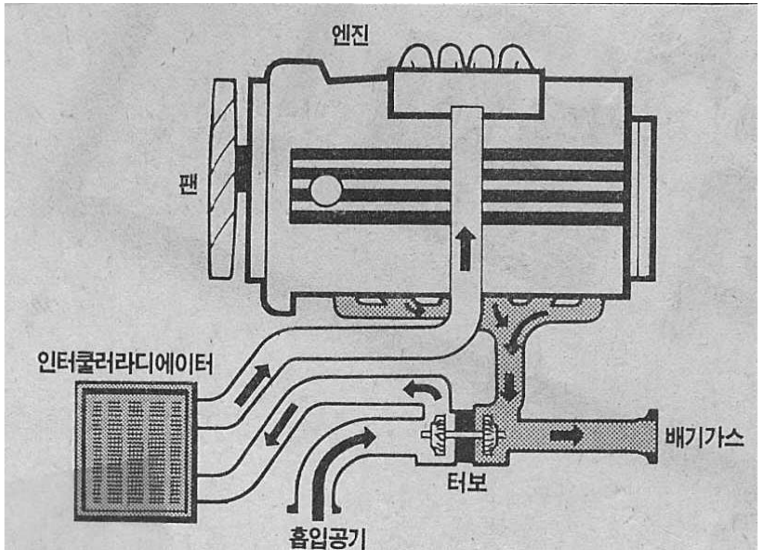
Movement of Fluid

Control of water flow of water clock using copper tubing during iron age
Principle of buoyancy by Archimedes
Water pump in Roman Period
Bernoulli's principle
Reynolds: Laminar flow and turbulent flow

Spoiler of a car
Water resistance against a boat
Sliding bearing, Hydrofoil, Magnetic head of a hard disc
Shape of a fish
Curve ball in baseball, Golf ball

Intercooler Turbo Charger





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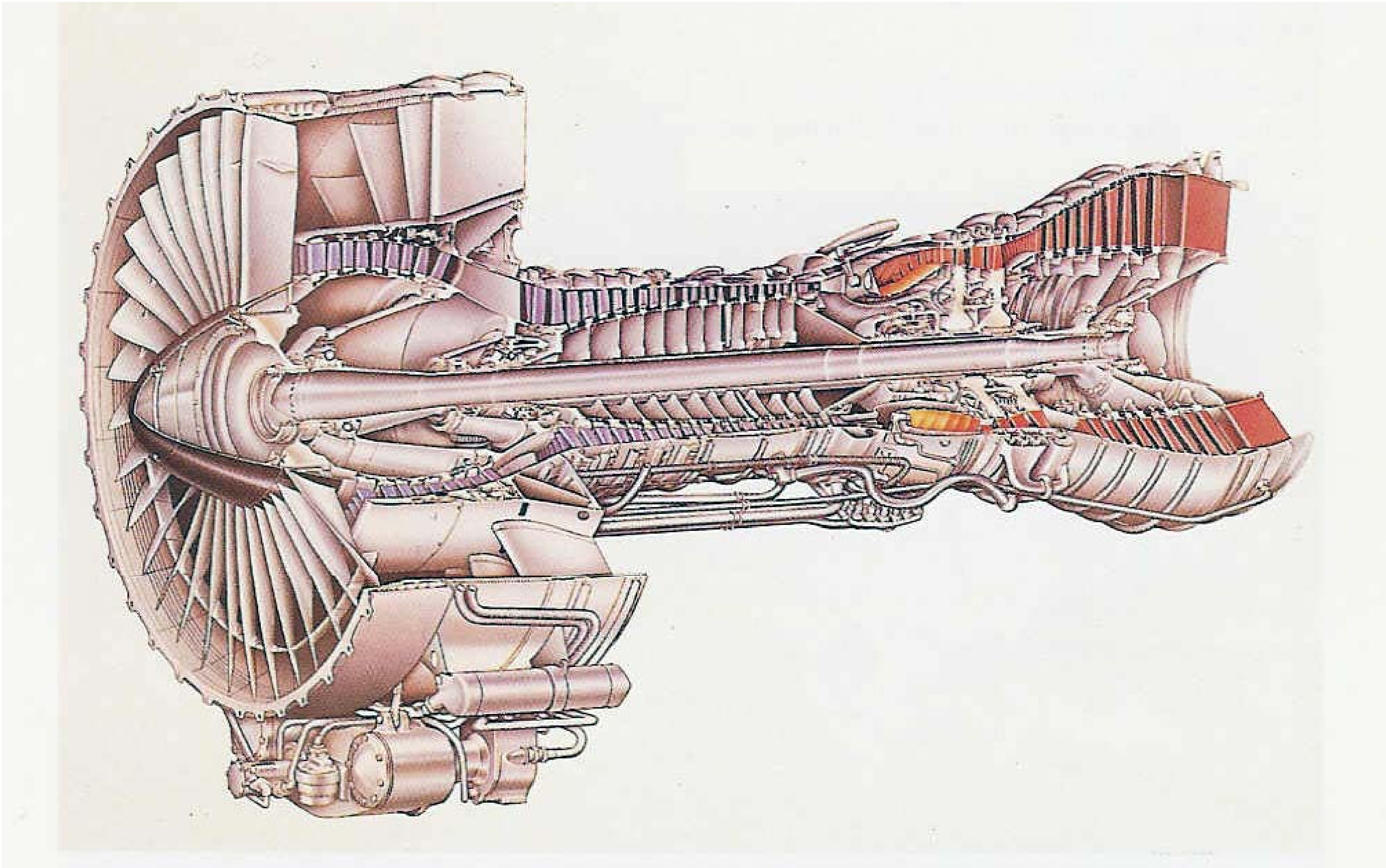
Turbine



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Thermodynamics

Utilization of Energy

Boyle, State of gas under pressure

Established during Industrial Revolution

- Study of property of steam and improvement of efficiency of steam engine

Turbocharger, Intercooler Turbocharger

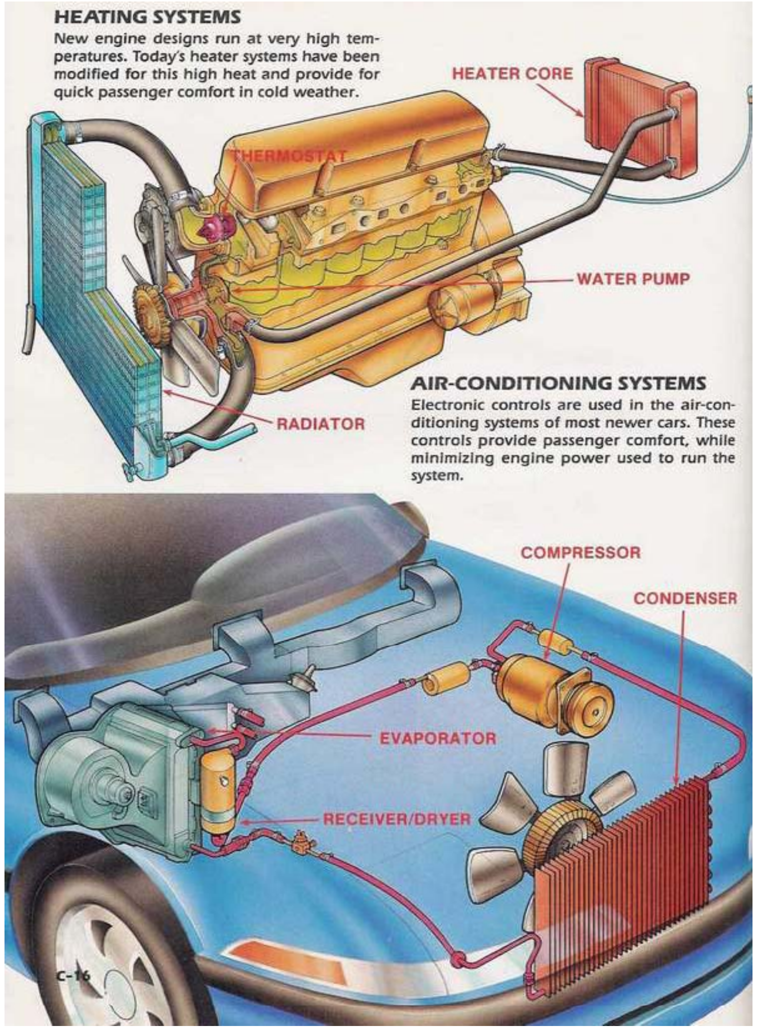
DOHC Engine

Fuel cell, Low pollution lean-burn engine

Heat and Energy System

Environmental facilities

Air Conditioning System

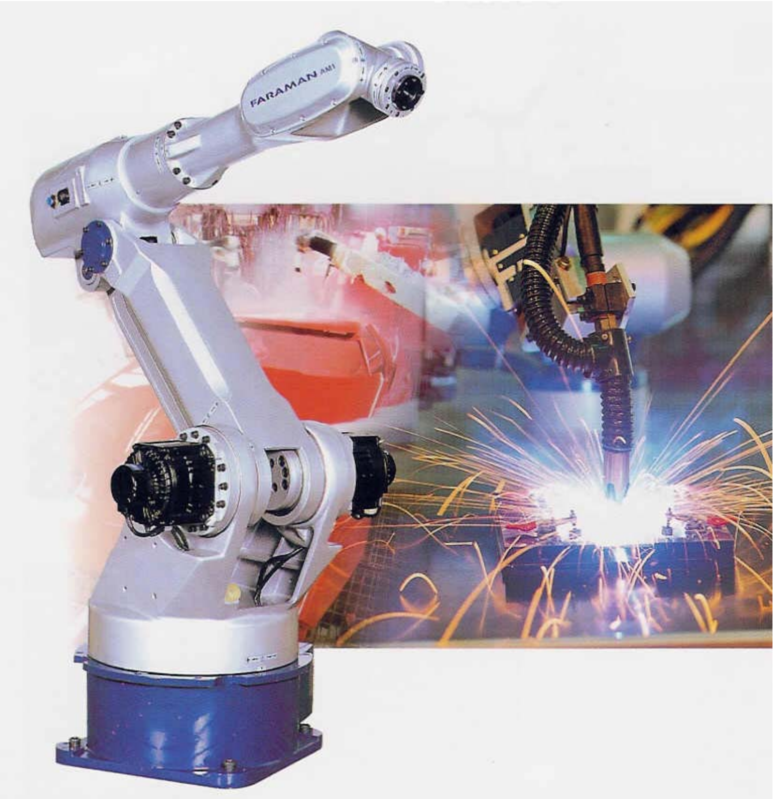


Heat Transfer

Transfer and utilization of heat.
Dispersion, concentration and insulation of heat

Refrigerator, Air conditioner, Heater, Oven, Cooker
Rectifier of Computer, Chip, Radiator of automobile
Laser cutting, Light condenser
House Insulator, Double window panel

Industrial Robots



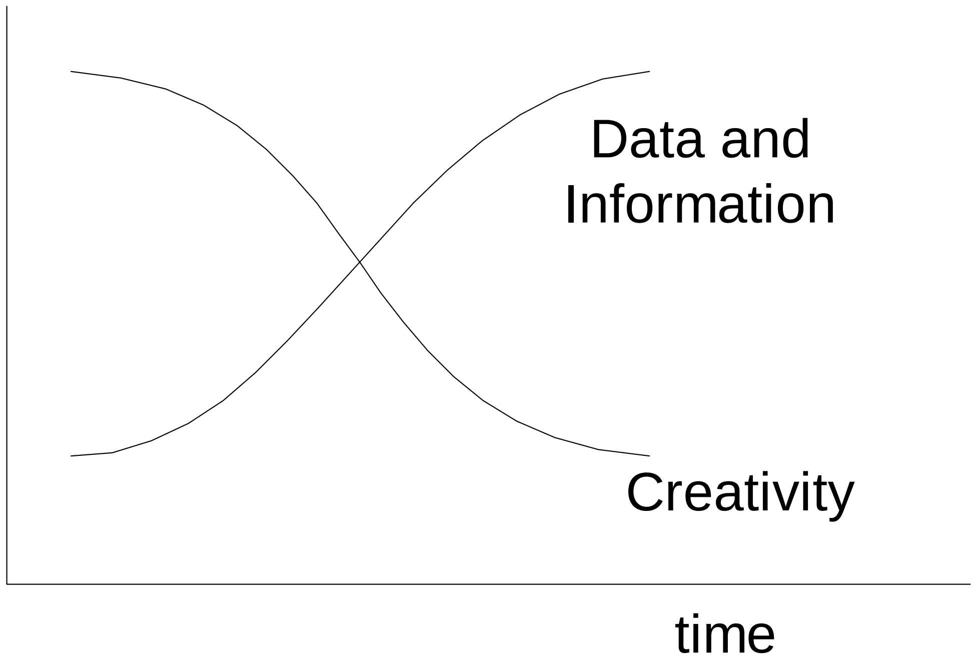
Kinematics

A mechanism is an assembly of several mechanical elements which move according to the motion of one element.

Kinematics is the study of relative geometric motion of the elements.

Valve and cam of engine
Movement of robot arm
Relative movement of gears
CD player
Steering system

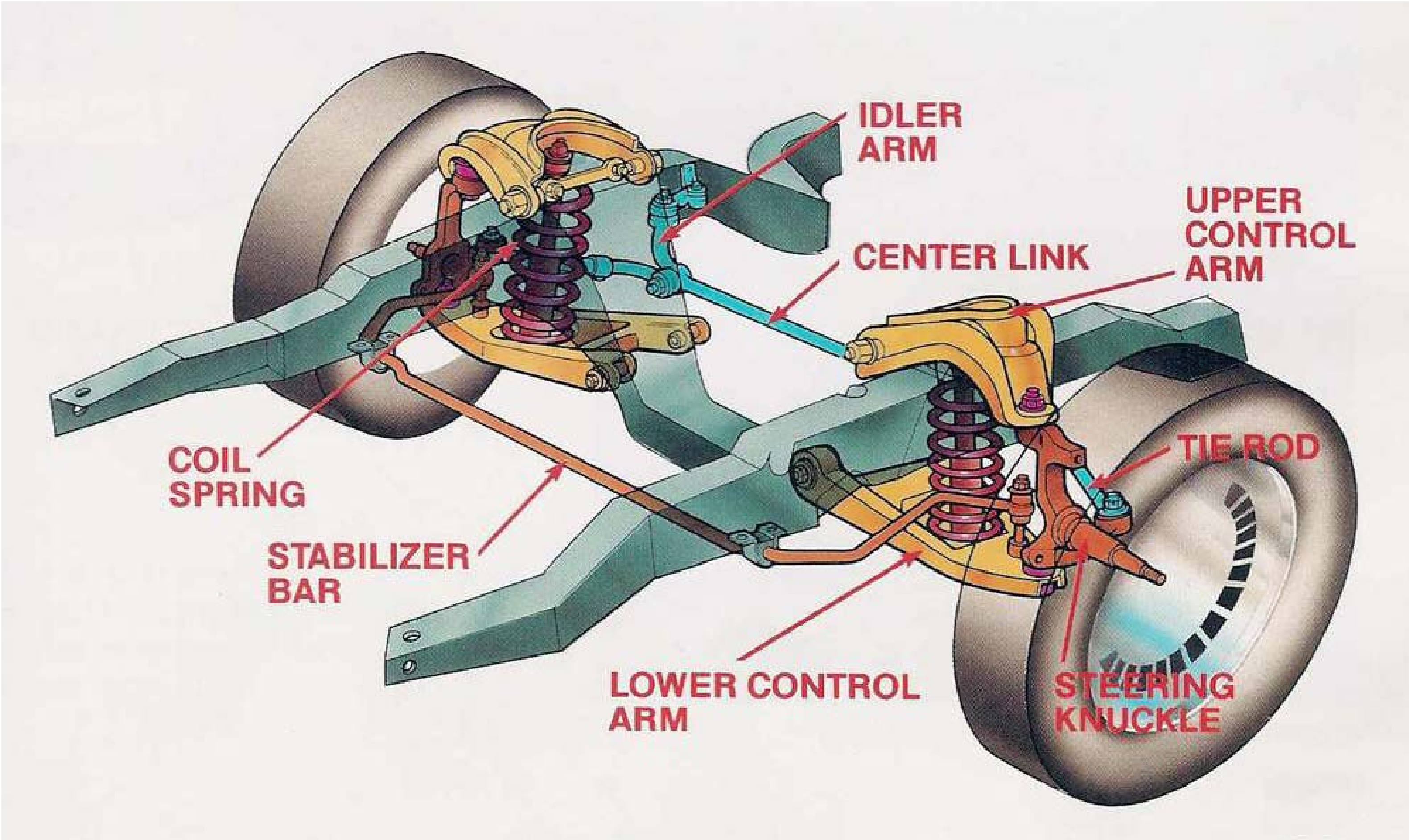
Design



Design is a process of devising a machine

- Creative conceptual design
- Detailed design
- Analysis using mechanics

Suspension


IDLER
ARM
UPPER
CONTROL
ARM
CENTER LINK
COIL
SPRING
TIE ROD
STABILIZER
BAR
LOWER CONTROL
ARM
STEERING
KNUCKLE

Dynamics

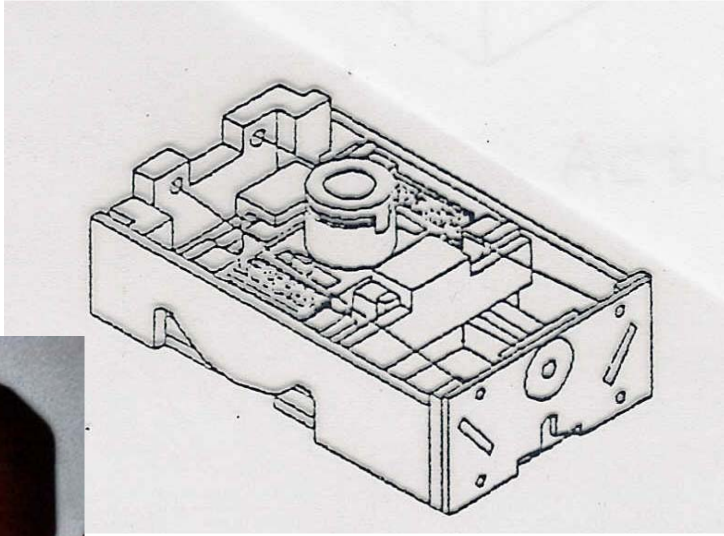
Movement and Vibration of Solid

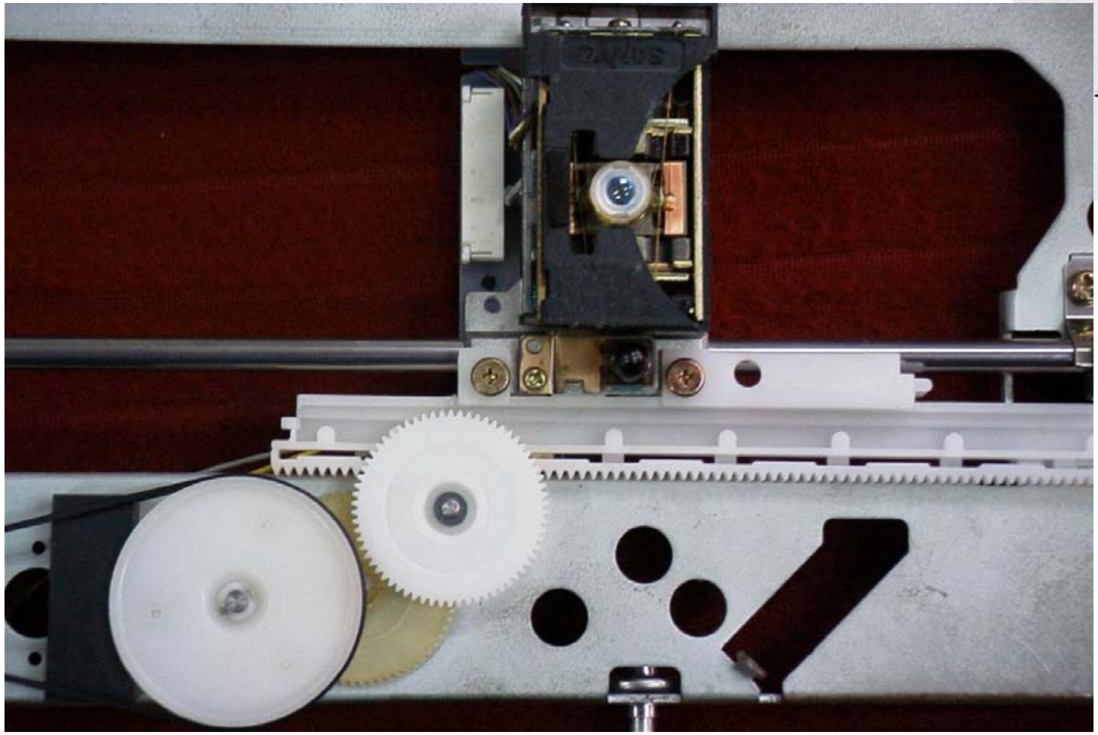
Newton's law of motion

Automobile suspension, Active suspension
Vibration, Noise, Acoustics

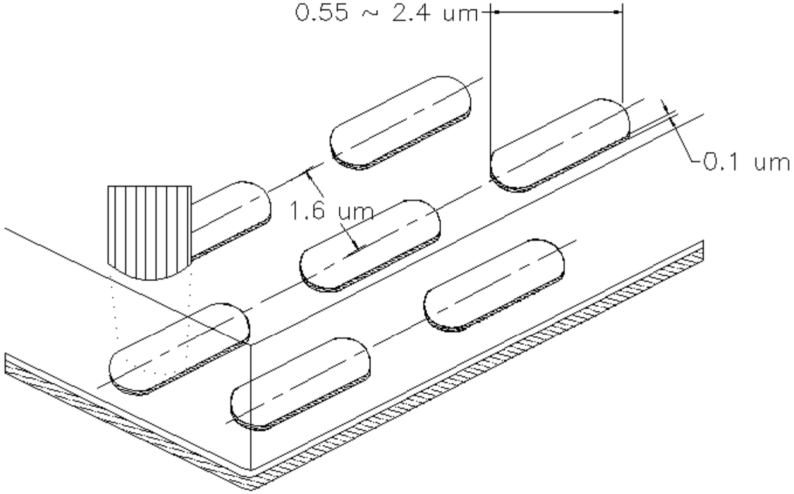
Tire Balancing, Vibration of Motor
Active noise control

CD Pick-up





CD Pick-up



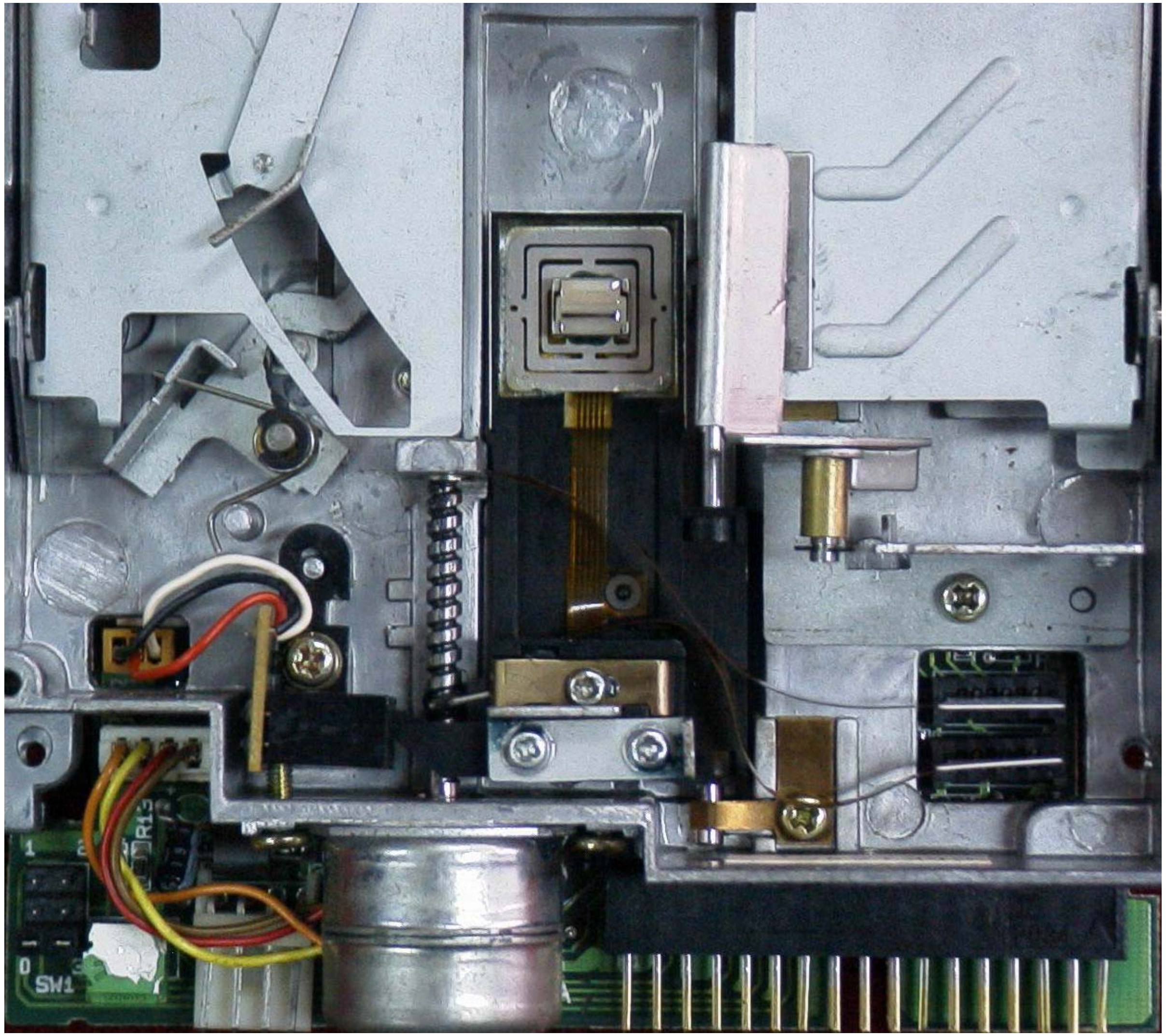
CD

Radius: 59 mm, Track Spacing: 1.6 μm

Baseball Filed

Radius: 100 m, Track Spacing: 2.7 mm

Floppy Disk Drive



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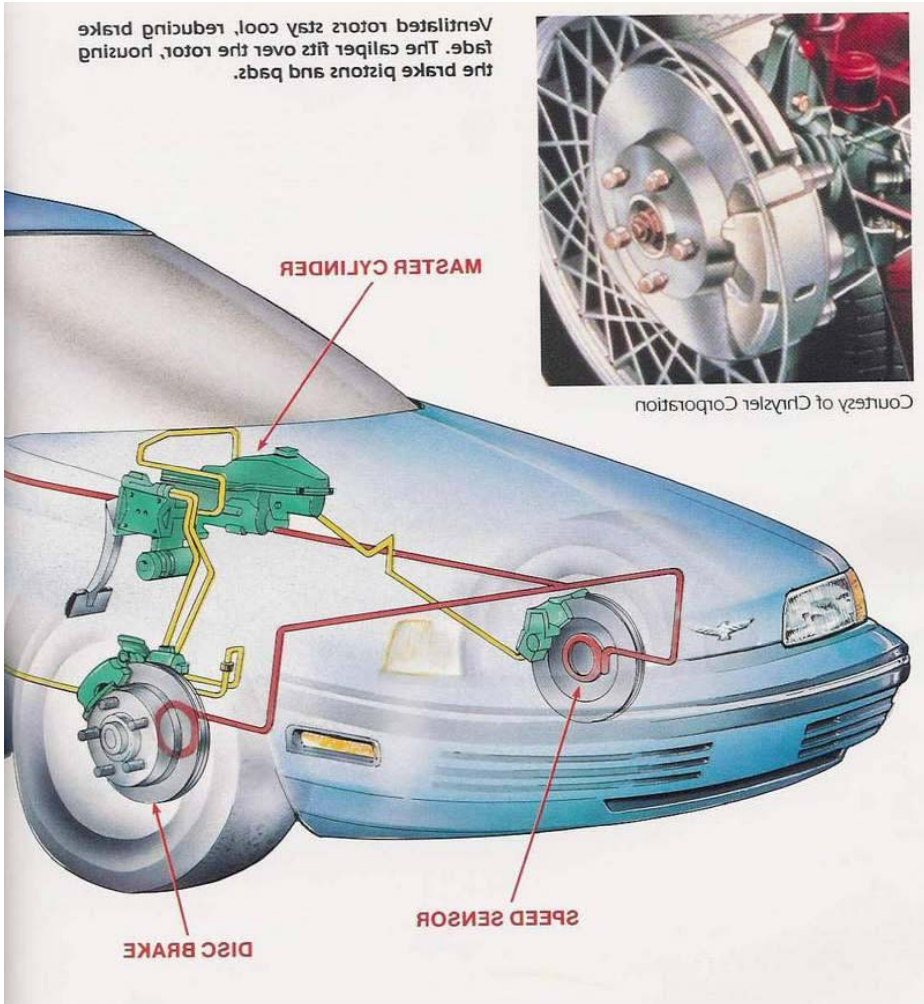
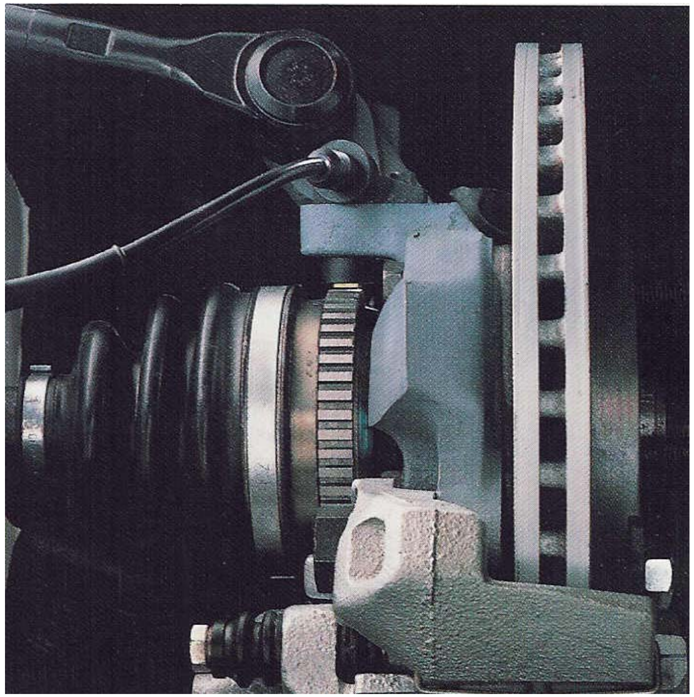
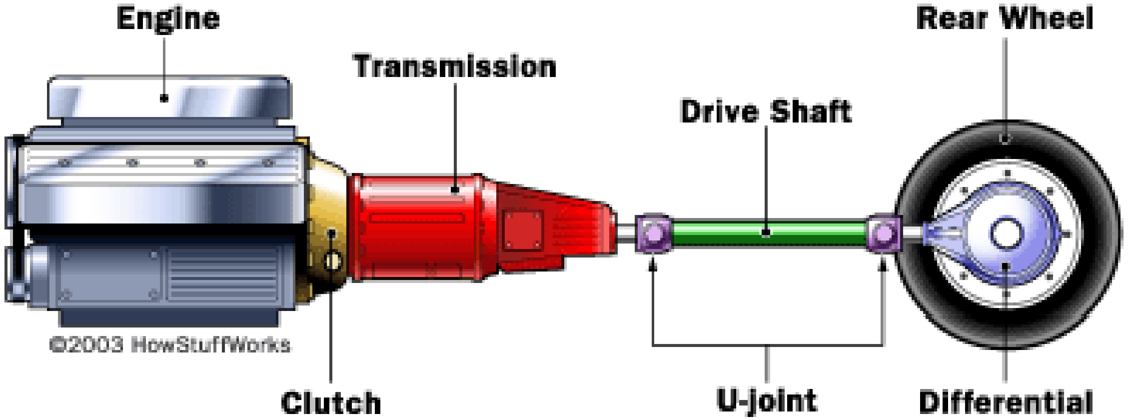
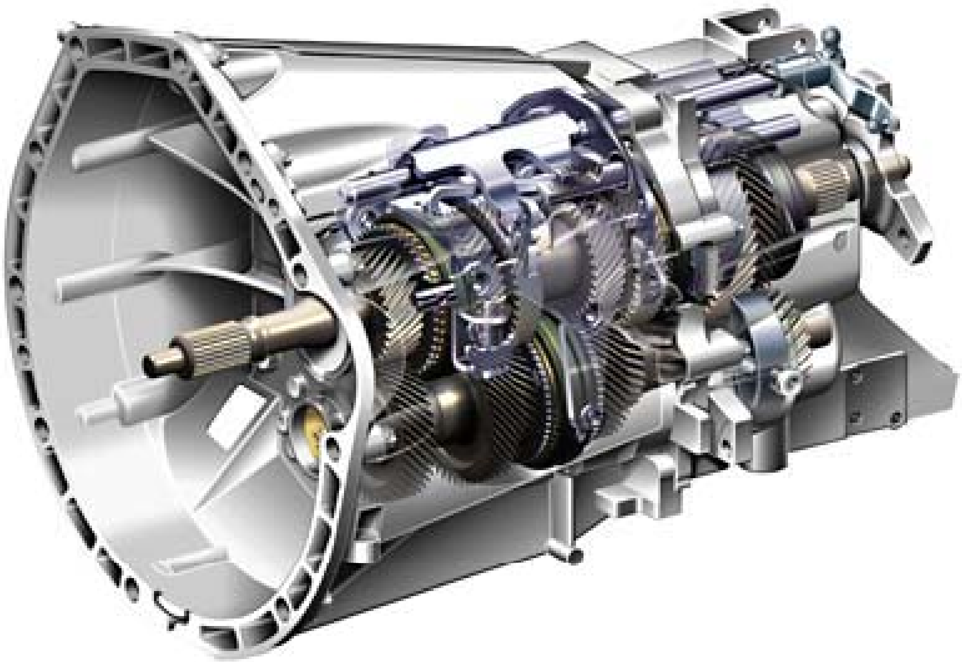
ABS System


Ventilated rotors stay cool, reducing brake fade. The caliper fits over the rotor, housing the brake pistons and pads.
MASTER CYLINDER
Courtesy of Chrysler Corporation
SPEED SENSOR
DISC BRAKE



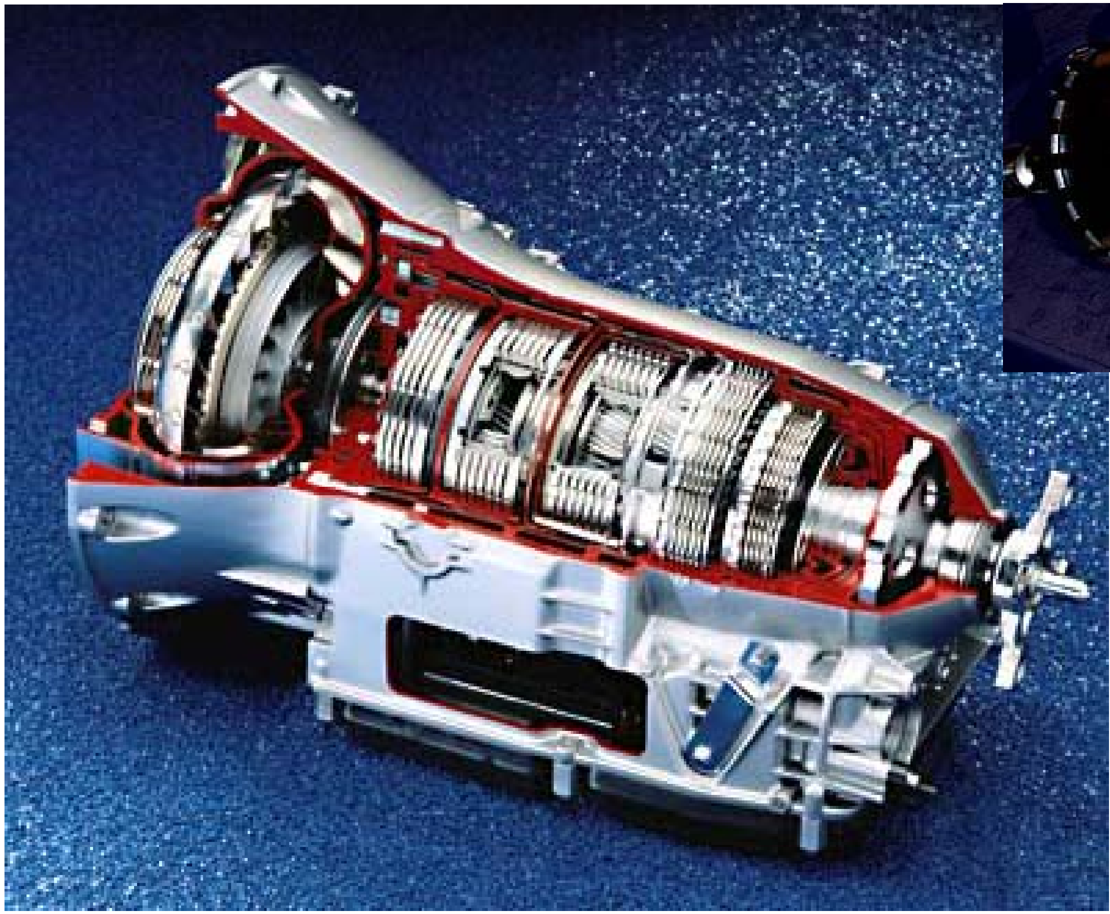
Manual Transmissions





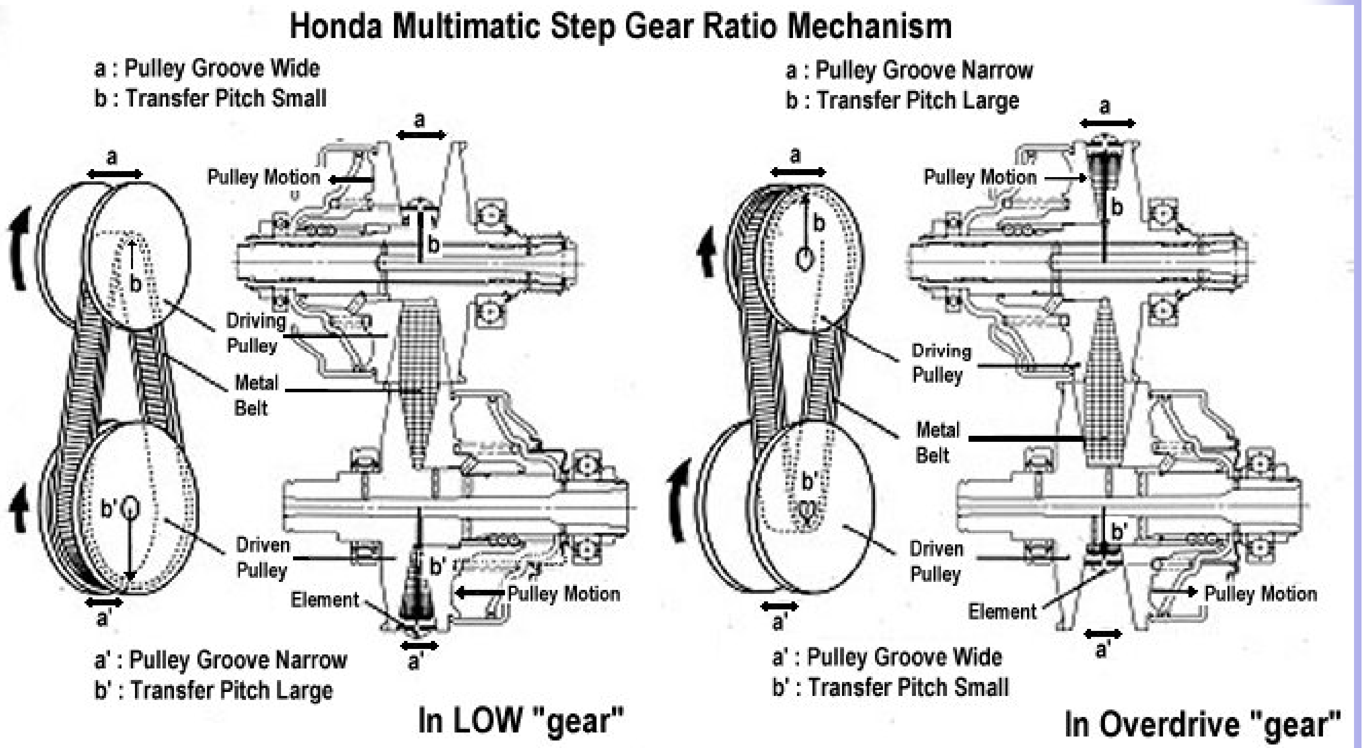
Mercedes-Benz C-class sport coupe, 6 speed manual transmission

Automatic Transmissions



Mercedes-Benz CLK,
automatic
transmission

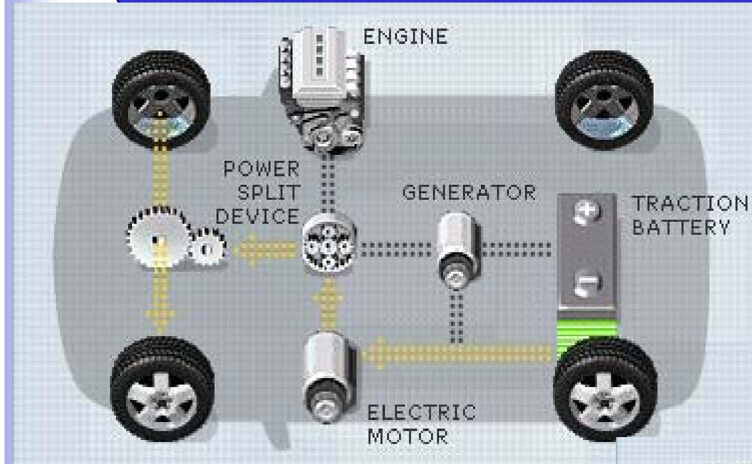
Continuously Variable Transmissions



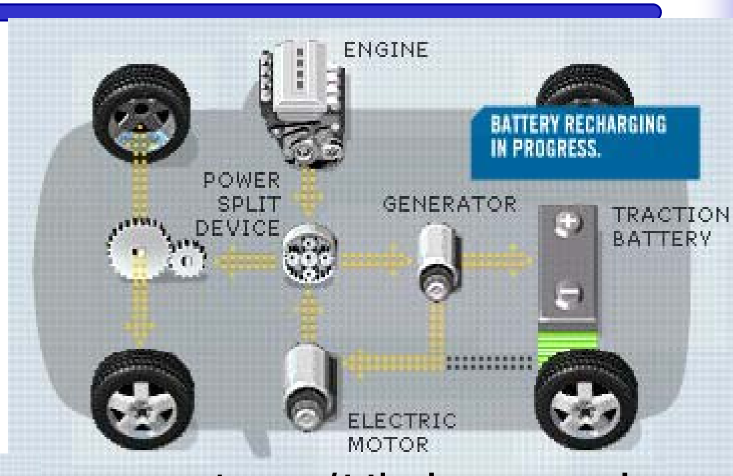
Honda Insight, CVT

PREMA
PRECISION ENGINEERING & MANUFACTURING

Hybrid Automotive (Prius)

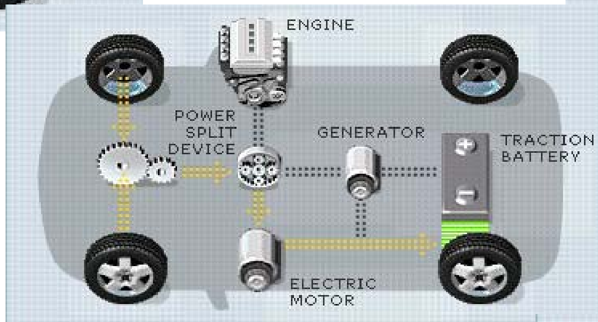


Low speed



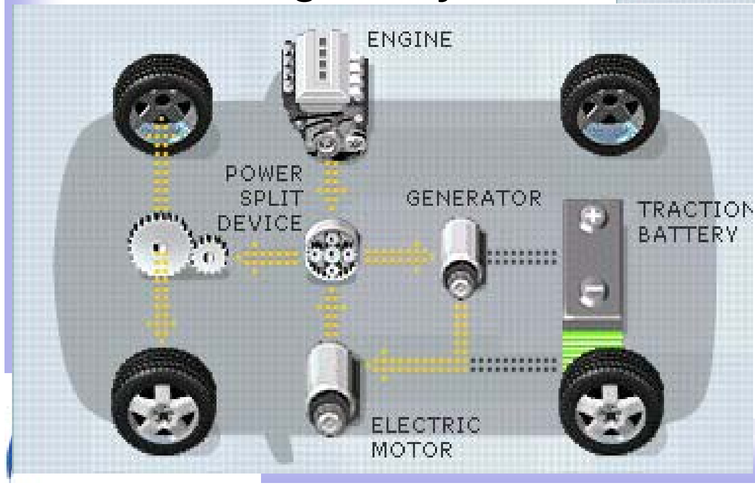
Low/High speed

Highway

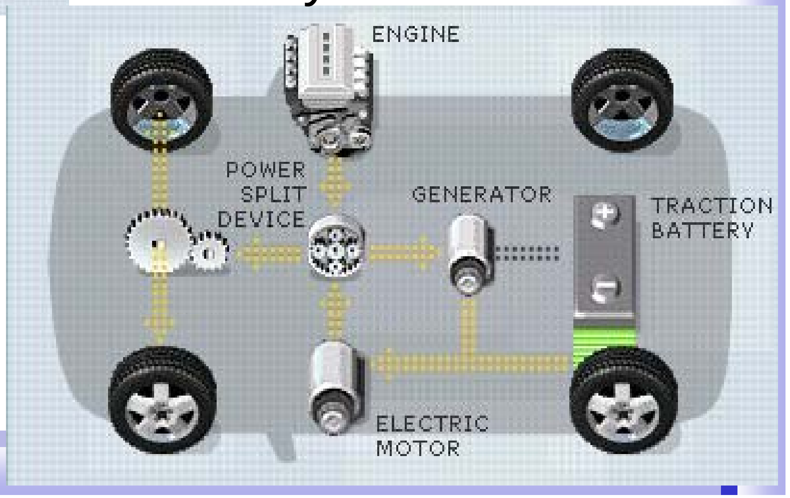


Brake

Highway



Heavy acceleration



Control and Mechatronics

From the Steam Engine of James Watt

Governor measuring RPM using centrifugal force

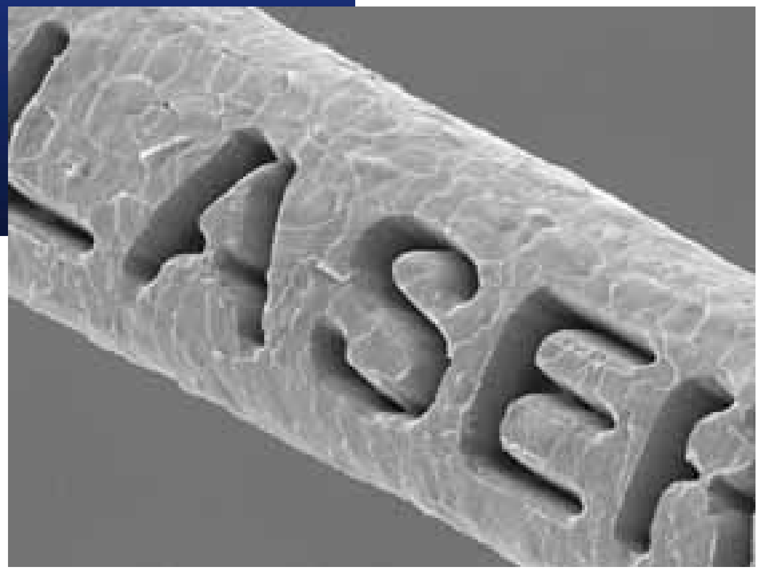
Automatically controlling the machine to function properly

Thermostat
(Engine Control Unit (ECU)
Anti-lock Braking System (ABS), Airbag

Mechatronics is a compound word of Machine & Electronics
Electronically controlled machine
Robot, Automation machine, Electronic Products

Laser Beam Machining

115 µm blind via through 50 µm polyimide using 355 nm laser.

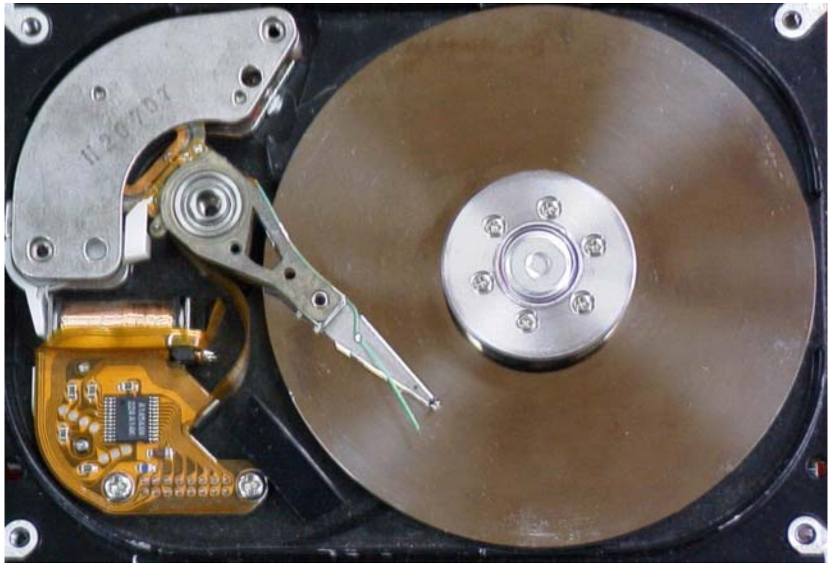


Diamond Turned Products

- Application

  Telescopic mirror, laser printer drum, scanner mirror, hard disk, mold for aspheric lens

Hard Disk Flying Height



Hard Disk
Pick-up Length: 1.2 mm, Flying Height: 50 nm

B747
Body Length: 70.5 m, Flying Height: 2.9 mm

Limit Technology

A 50 nm spot in 12 inch wafer

A baseball in Korea

Manufacturing

Manufacturing process
Machine control and communication
Manufacturing planning

Manufacturing Process:
Casting, Forming, Machining
Technical and economical aspects

Laser disk, FAX, Laser printer, Semiconductor, Missile guidance system

USA: Defense industry
Japan: Information and communication device

Application to Automobile

Automobile: Body, Power generation

Outer body design
Structure design: Rigidity, Crash
Wind tunnel test

Engine design
Transmission: Manual, Automatic, CVT
Suspension, Steering: ABS, TCS, 4WS
Air conditioning
Acoustics

Importance of ME

Mechanical engineering is experience oriented.

- Trial and error
- Long history

Far reaching influence of mechanical engineering industry

- 15,000 parts are assembled to make a car

Mechanical engineering Industry

Germany:	41.4%
Japan:	34.6%
USA:	34.4%
Korea:	26.9%
World Average:	29.4%

Mechanical Engineering

Thank You