

Fall 2022 (111-1)

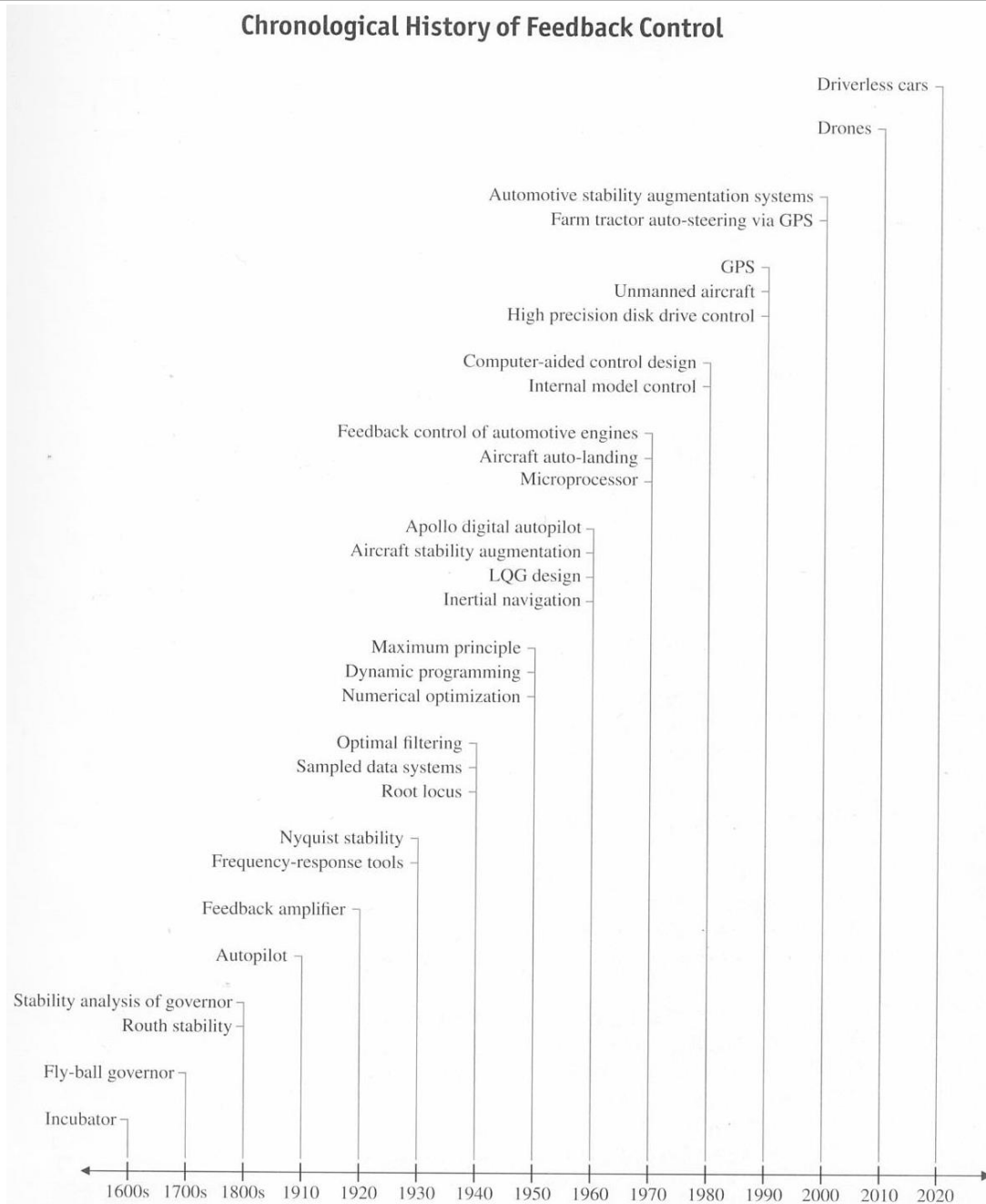
控制系統  
Control Systems

Unit 1C  
A Brief History of Feedback and Control

Feng-Li Lian

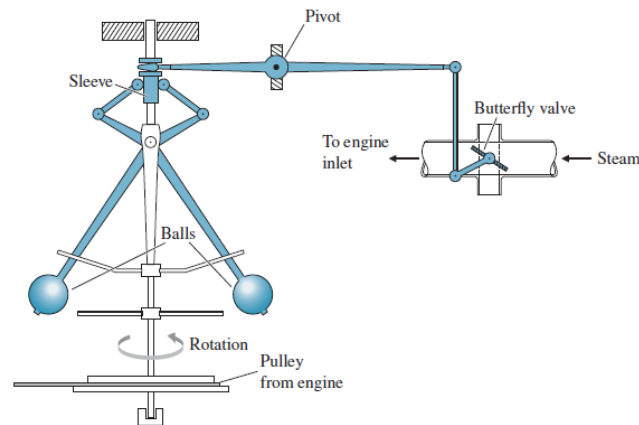
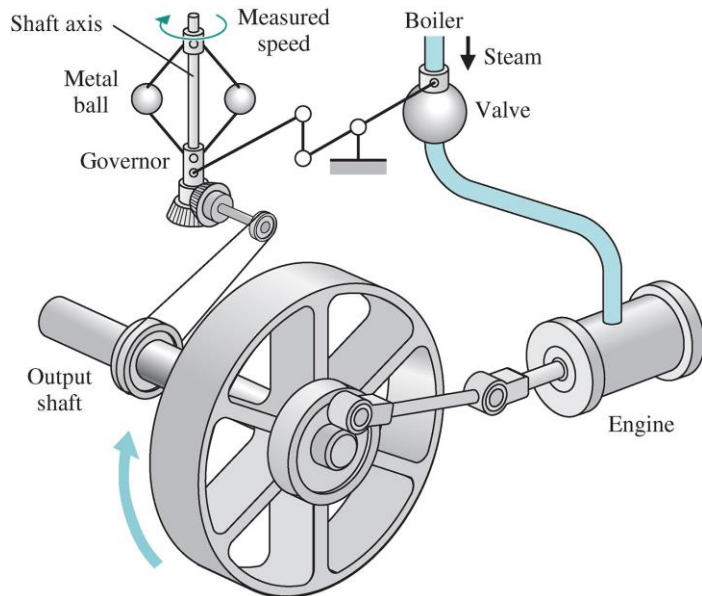
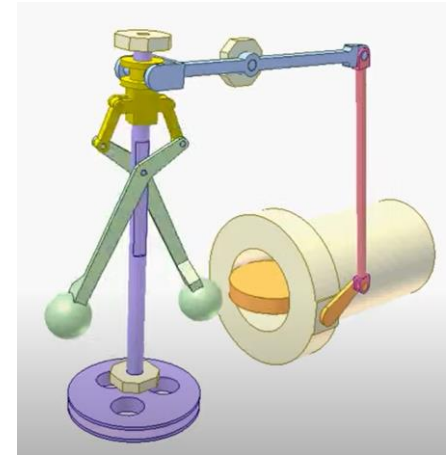
NTU-EE

Sep 2022 – Dec 2022



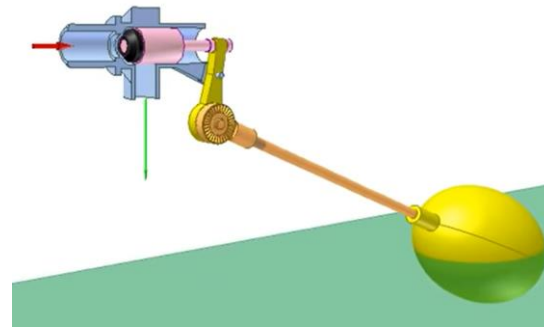
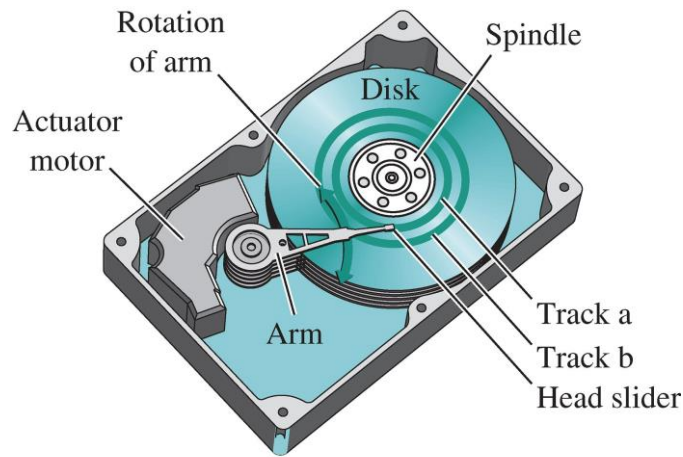
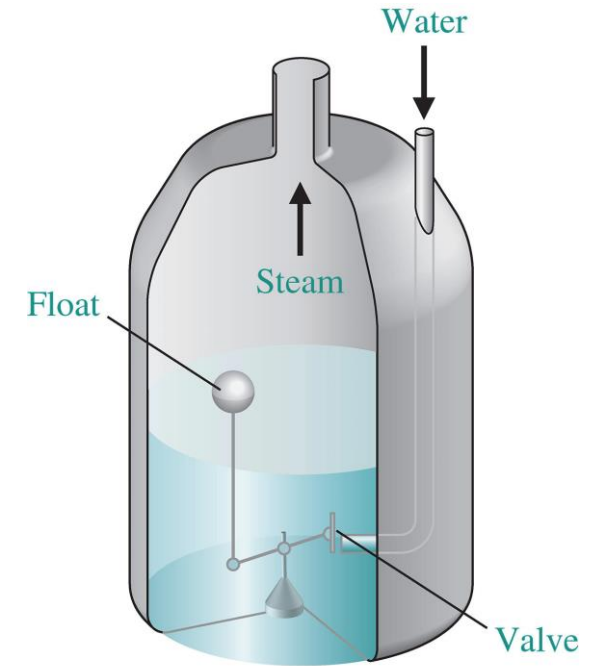
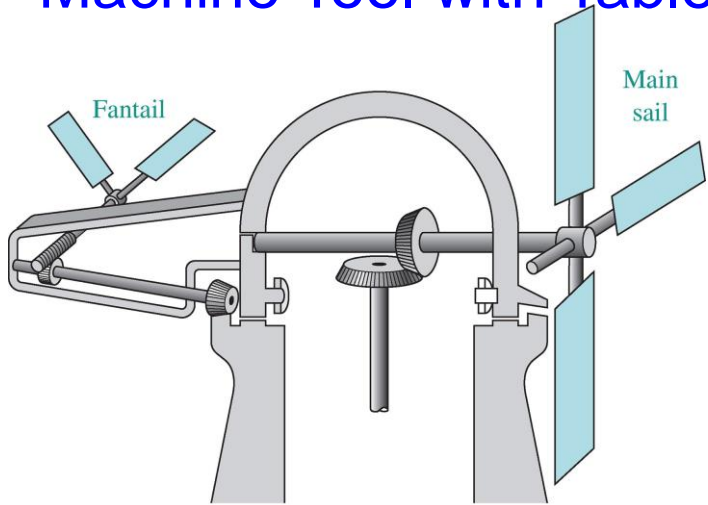


Flyball governor for flow control  
<https://www.youtube.com/watch?v=SiYEtnZLSs>

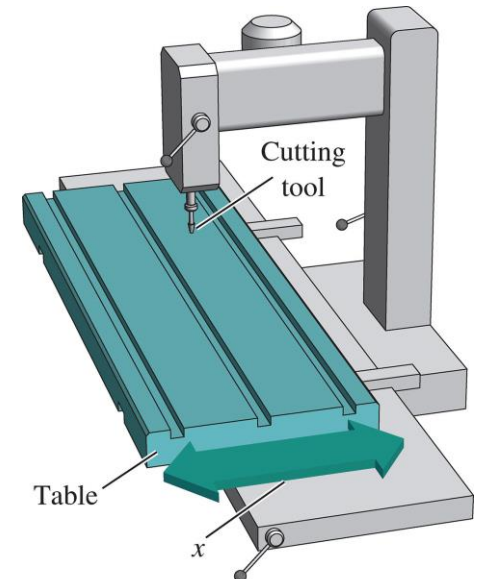


Centrifugal Governors  
<https://www.youtube.com/watch?v=B01LgS8S5C8>

- Water-Level Float Regulator
- Automatic Turning Gear for Windmills
- Disk Drive
- Machine Tool with Table

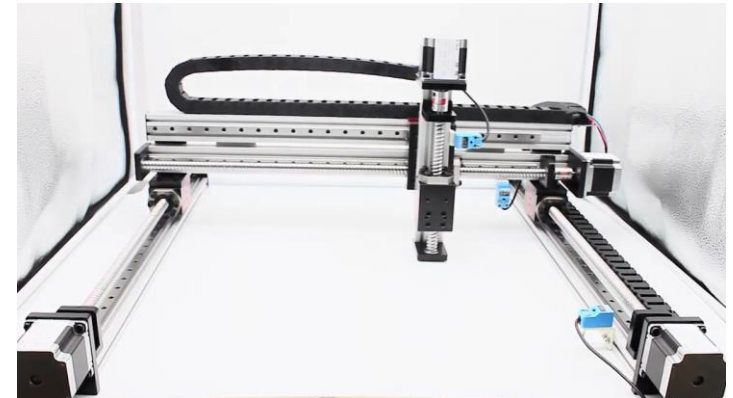
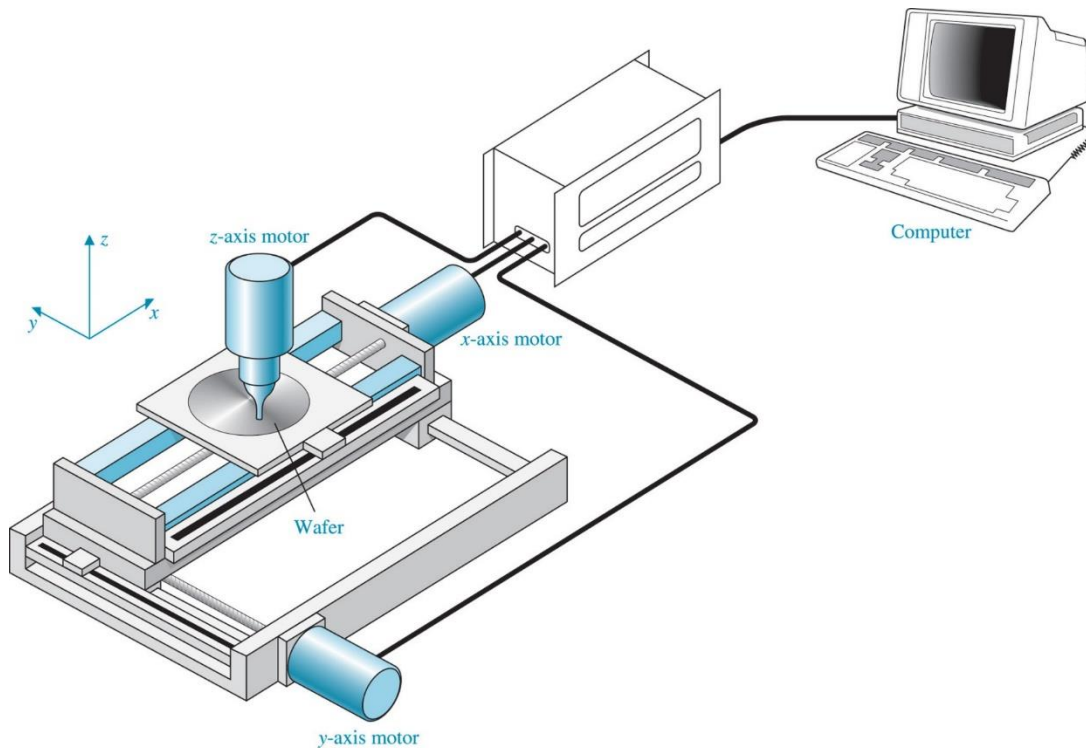


Water tank automatic valve  
<https://www.youtube.com/watch?v=TTad0HzrQt8>



(b)

- A **three-axis** control system for inspecting individual **semiconductor wafers** with a highly sensitive **camera**.



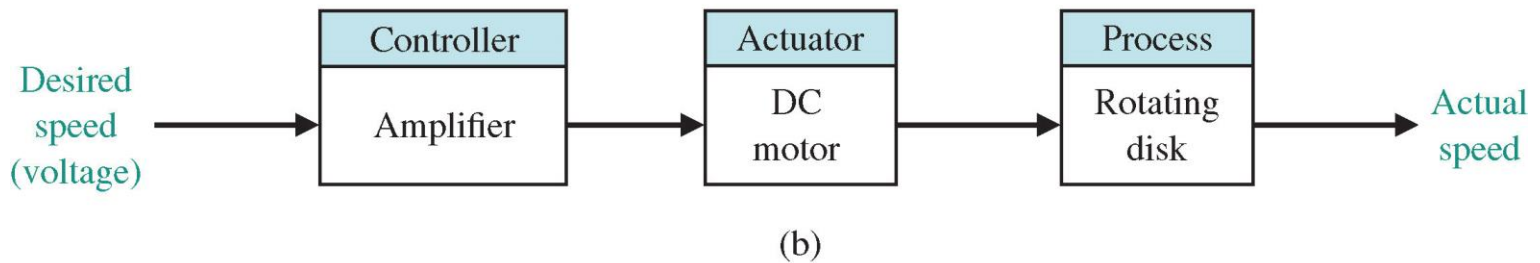
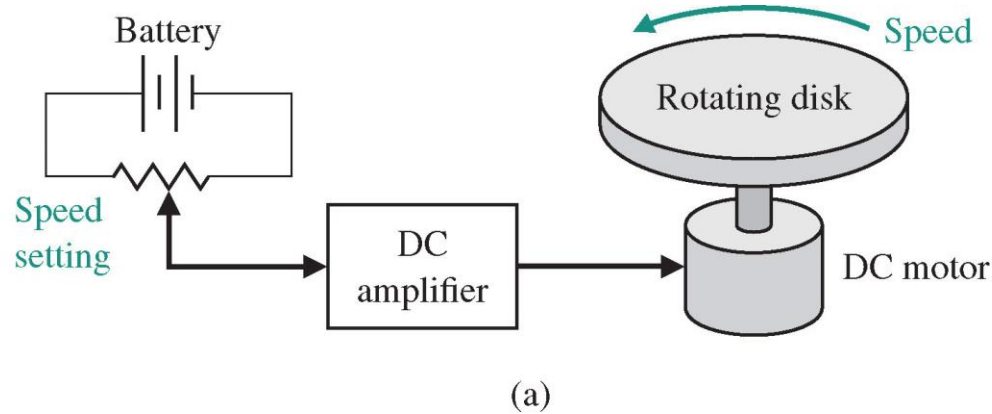
UMot 3-Axis XYZ Table Gantry Robot

<https://www.youtube.com/watch?v=CJtDBQ8aQwQ>

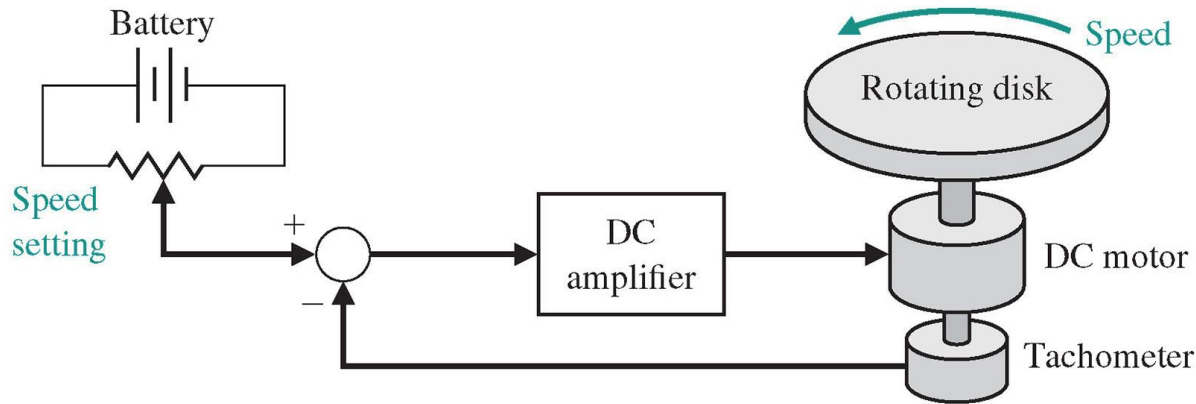




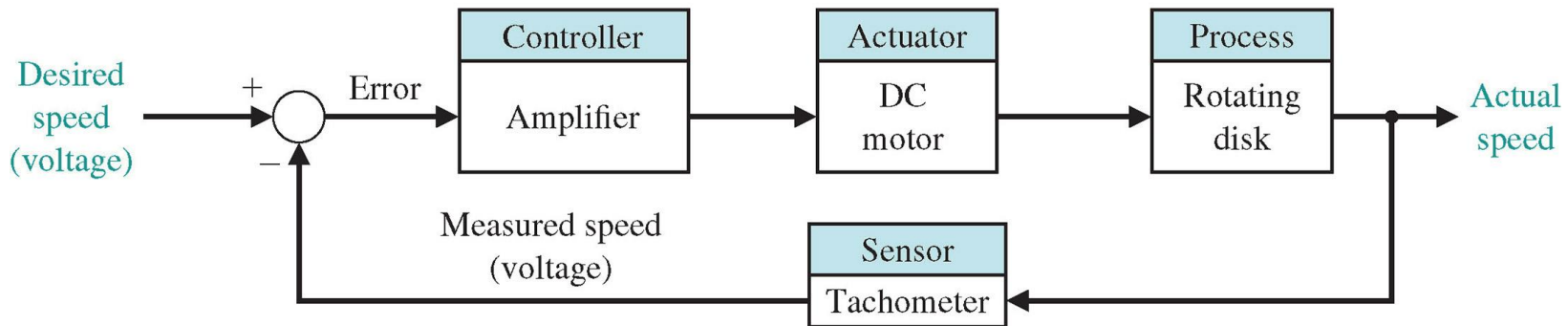
- **Open-Loop Control** of the Speed of a Rotating Disk
- **(Without Feedback)**



## ■ Closed-Loop Control of the Speed of a Rotating Disk



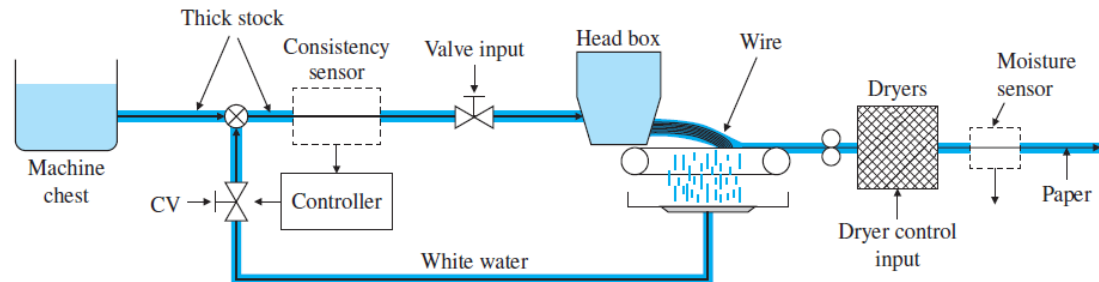
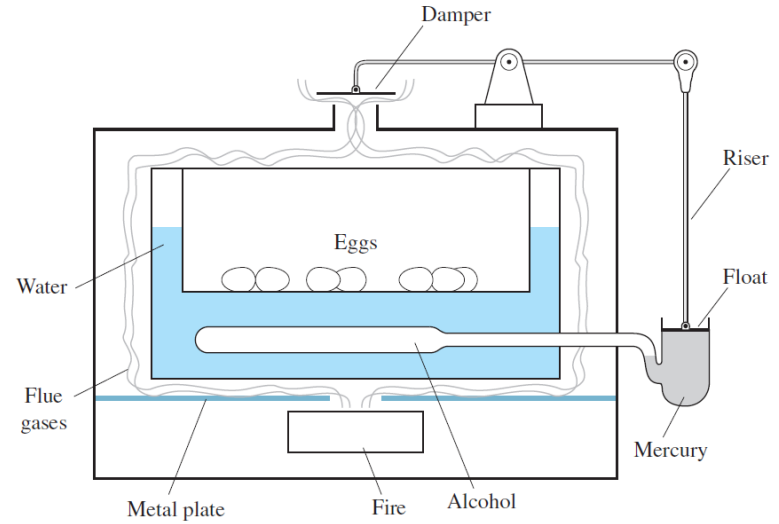
(a)



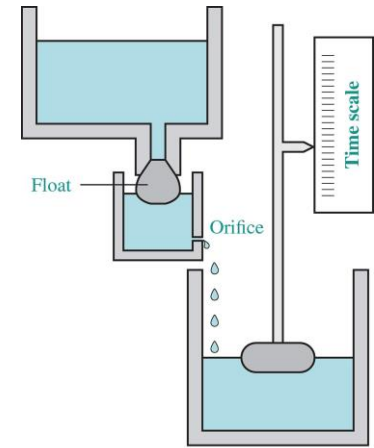
(b)



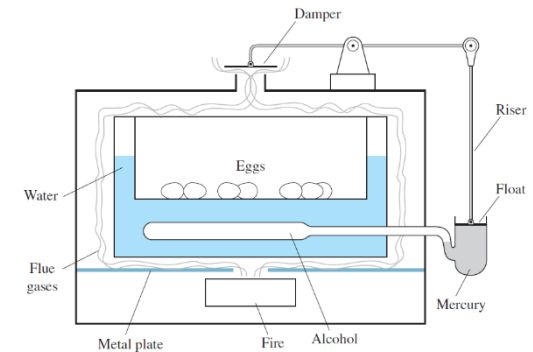
- Drebber's incubator for hatching chicken eggs
- A papermaking machine



- B.C.200 Greece  
Float regulator mechanism
- B.C.50 Middle East  
Water clock



- 1620 Cornelis Drebbel, Holland  
First feedback system  
Temperature regulator



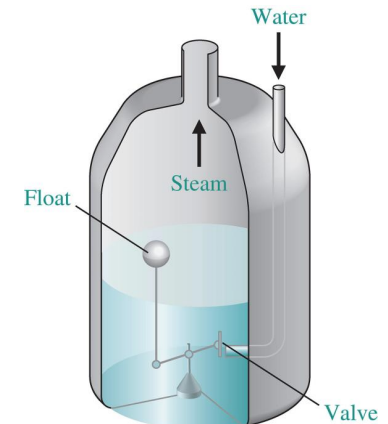
- 1462-1727 Sir Isaac Newton  
Mathematical modeling



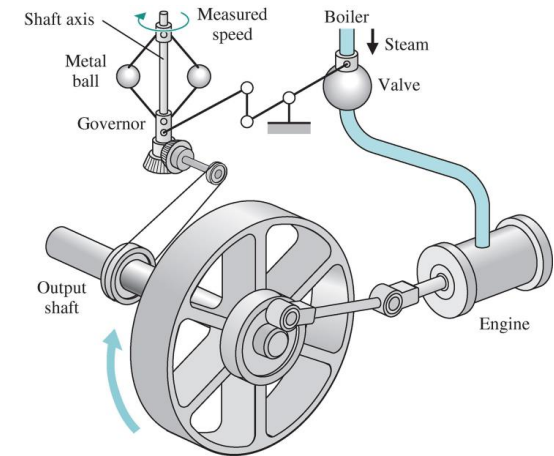
- 1685-1731 Brook Taylor  
Taylor series







- 1700 Dennis Papin  
Pressure regulator for steam boiler



- 1749-1827 **Pierre Simon Laplace**  
Laplace Transform
- 1769-88 **James Watt**  
First automatic controller  
Flyball governor
- 1765 **I. Polzunov**, Soviet Union  
First level regulator system
- 1831-1907 **Edward John Routh**  
Routh criterion
- 1859-1925 **Oliver Heaviside**  
Mathematical analysis
- 1868 **James Clerk Maxwell**  
Mathematical theory for control system



- 1890' **Lyapunov**, Soviet Union   
Stability theory
- 1930' **Nyquist, Bode, Black**; Bell Telephone Lab  
Electronic feedback amplifier
- 1889-1976 **Harry Nyquist**   
▪ 1932 Nyquist criterion
- 1898-1981 **Harold Black**   
▪ 1927 Negative feedback amp
- 1905-1982 **Hendrik Bode**   
▪ 1945 Bode diagram
- WWII period Automatic airplane pilot; Gun-positioning system,  
radar; Antenna control system; Military systems

- Post War      Frequency domain analysis  
                    Laplace transform method
- 1903-1957    John Von Neumann  
                    Basic operation of digital computer
- 1950'         Root locus method (Evans)  
                    Computer age open (digital control)  
                    Space age (Sputnik, Soviet Union)  
                    Maximum principle (Pontryagin)  
                    Optimal control  
                    Adaptive control system (Draper)
- 1960'         Dynamic programming (Bellman)  
                    State space method



- 1970'
  - Microprocessor based control system
  - Digital control system
- 1980
  - Neural network
  - Artificial Intelligent
  - Fuzzy control
  - Predictive control
  - LQG / LTR: Doyle & Stein
  - Remote diagnostic control system