

Spring 2021

控制系統
Control Systems

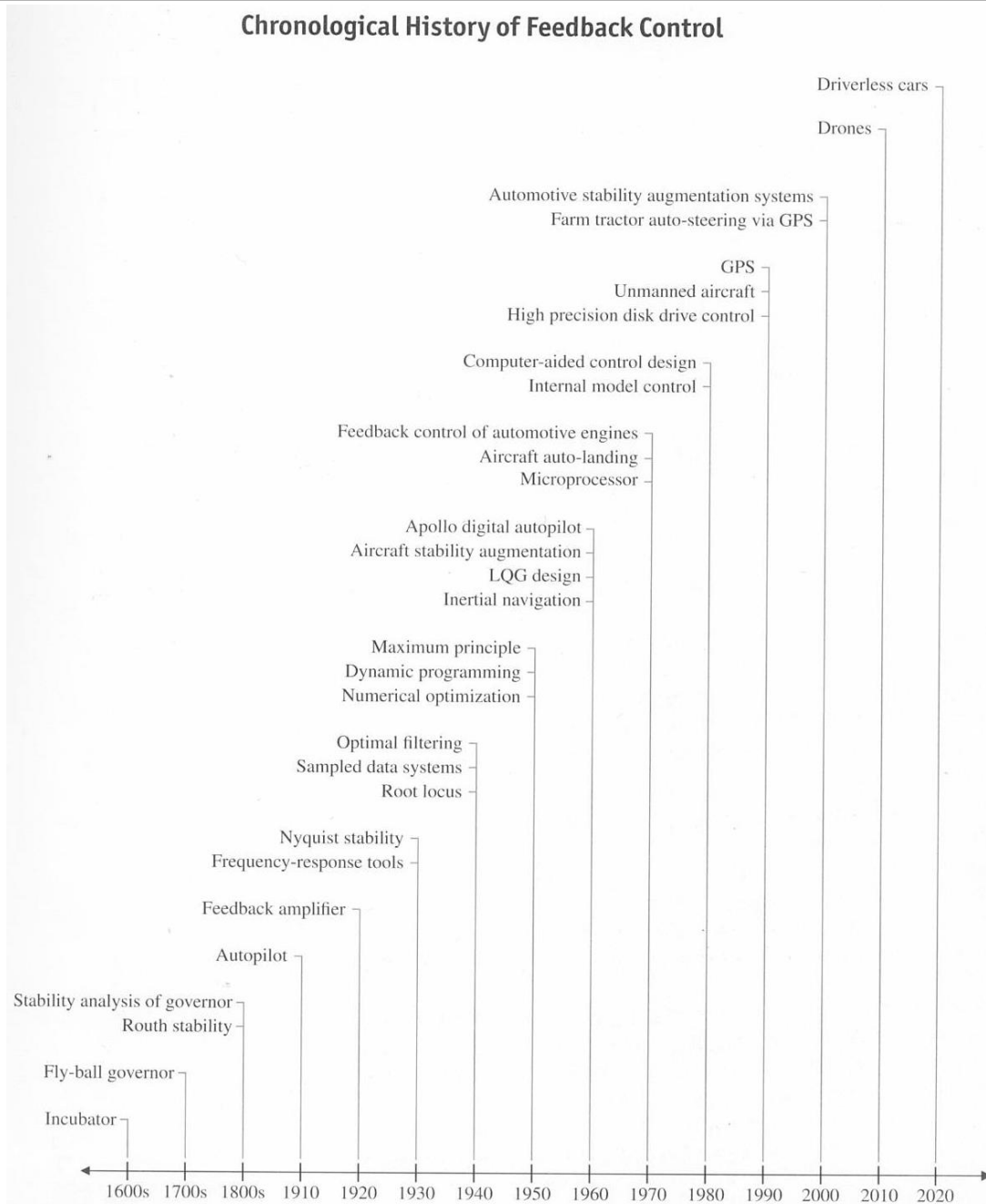
Unit 1C

A Brief History of Feedback and Control

Feng-Li Lian

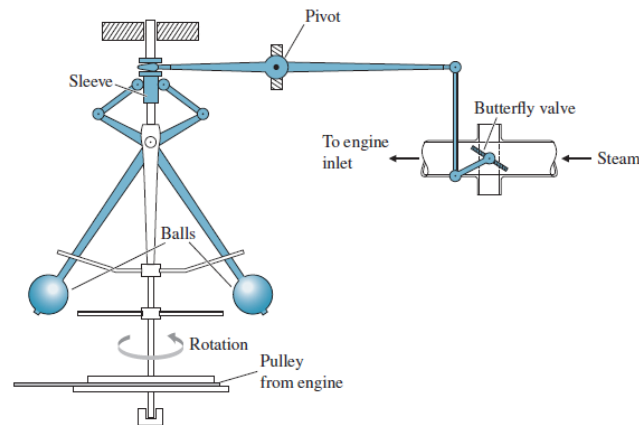
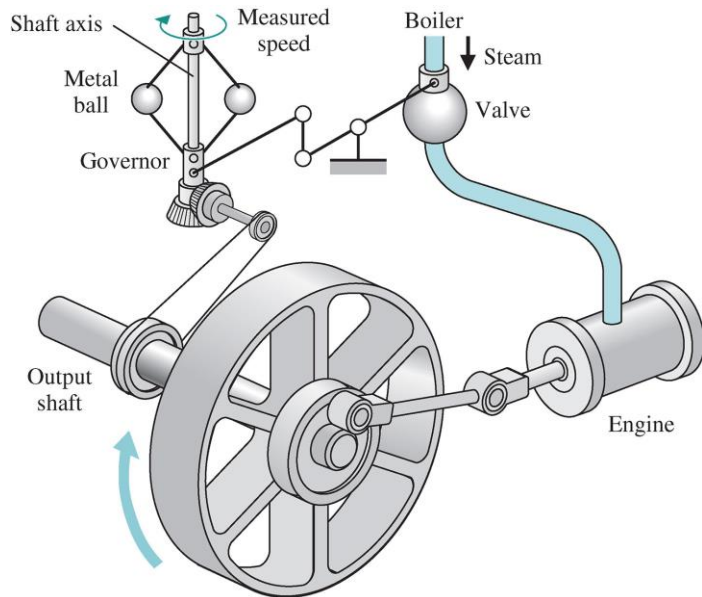
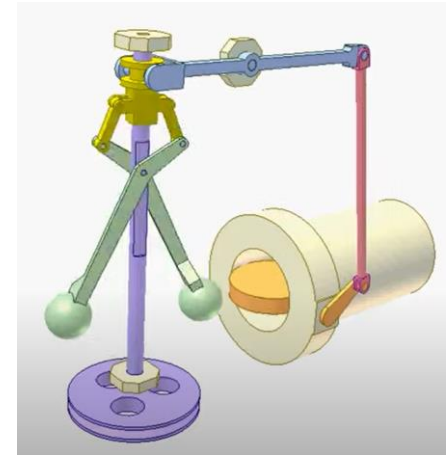
NTU-EE

Feb – Jun, 2021



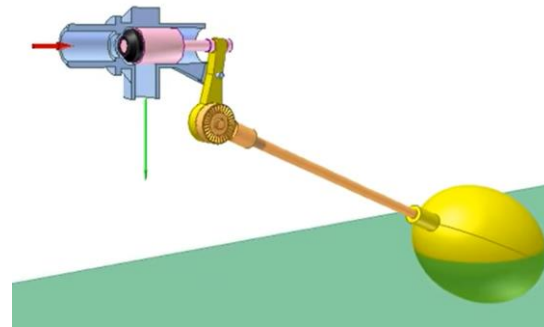
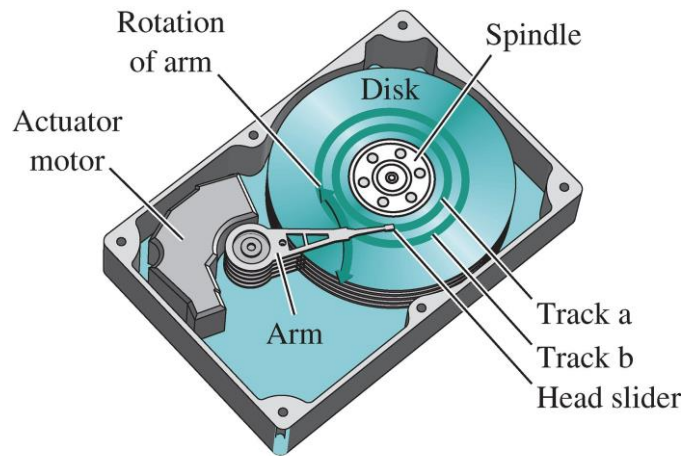
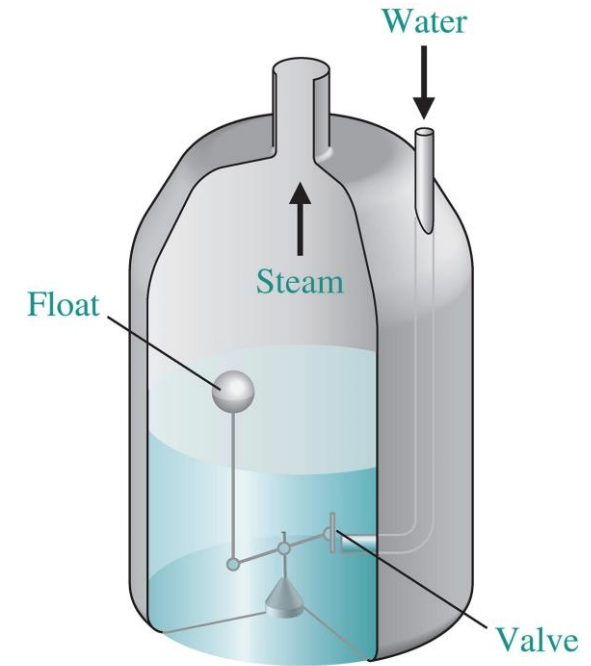
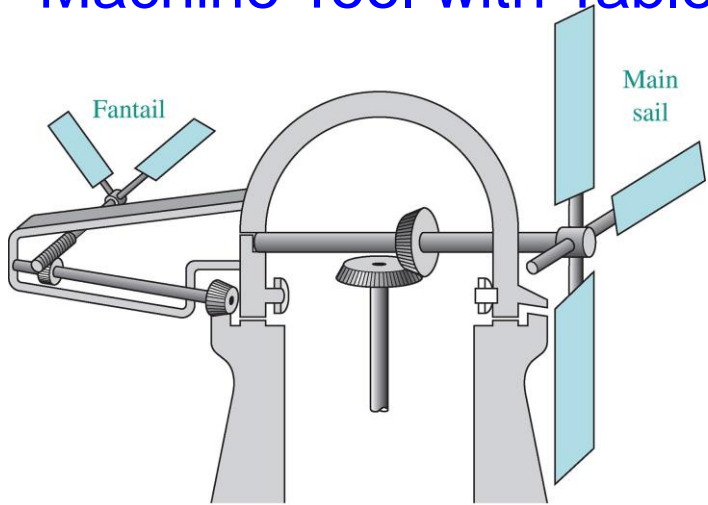


Flyball governor for flow control
<https://www.youtube.com/watch?v=SiYEtnZLSs>

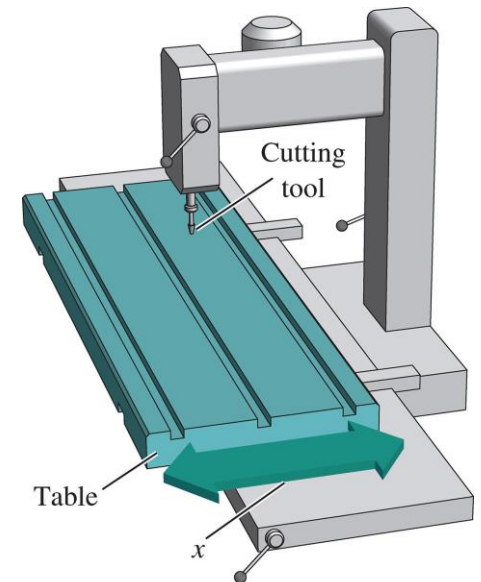


Centrifugal Governors
<https://www.youtube.com/watch?v=B01LgS8S5C8>

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

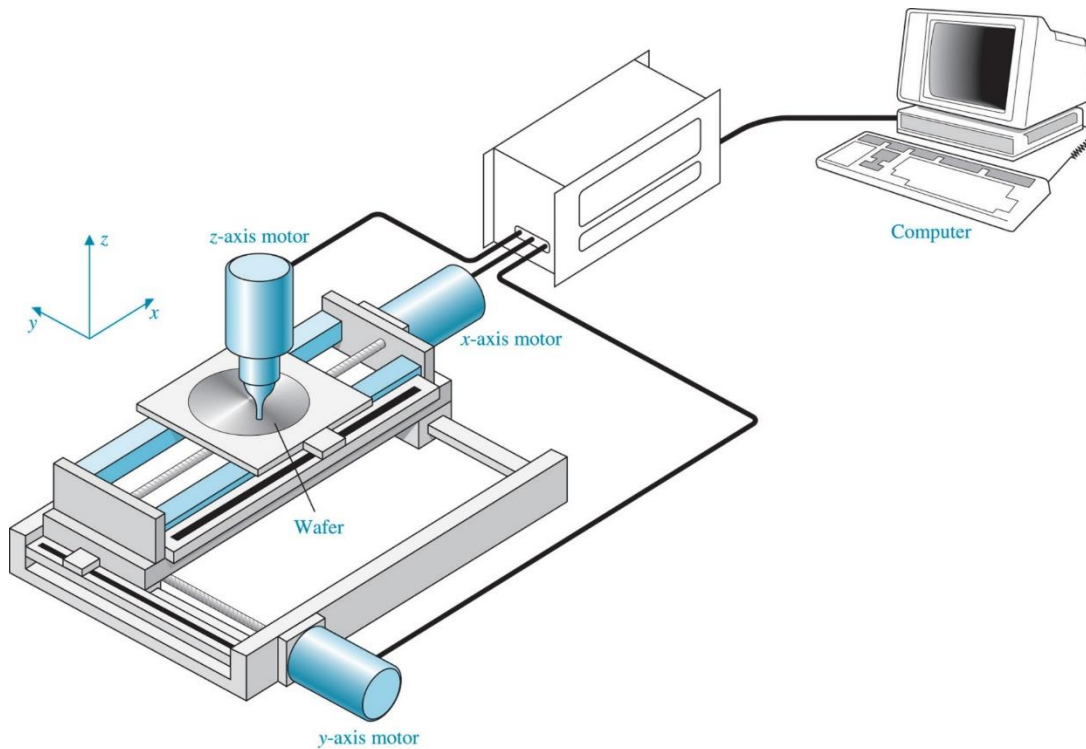


Water tank automatic valve
<https://www.youtube.com/watch?v=TTad0HzrQt8>

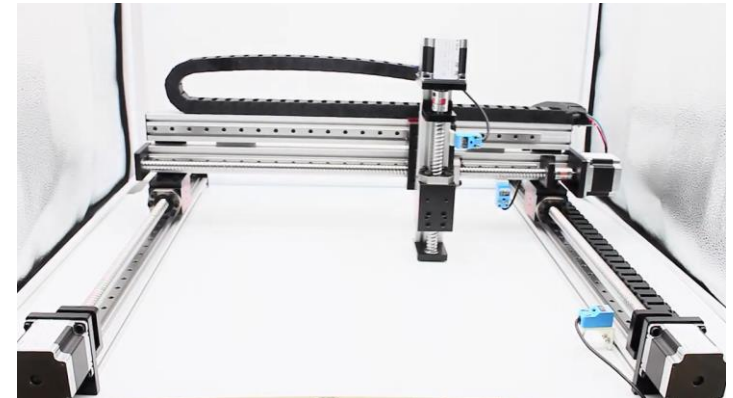


(b)

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

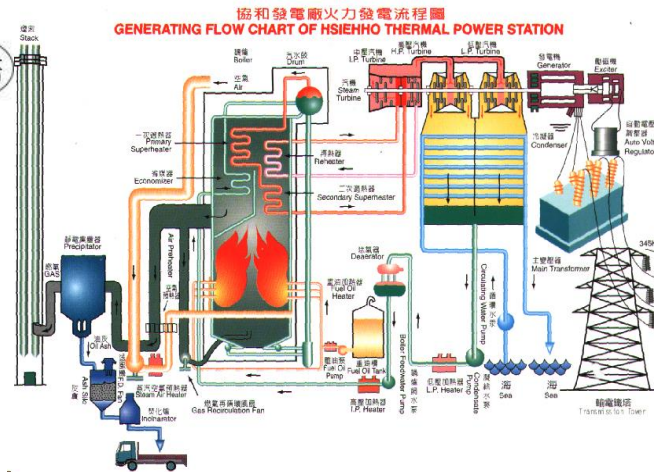
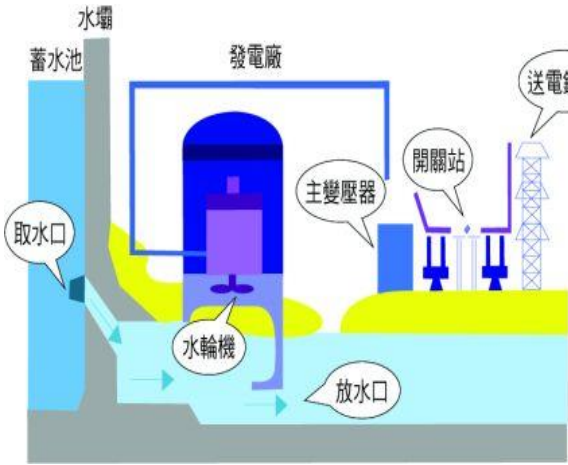


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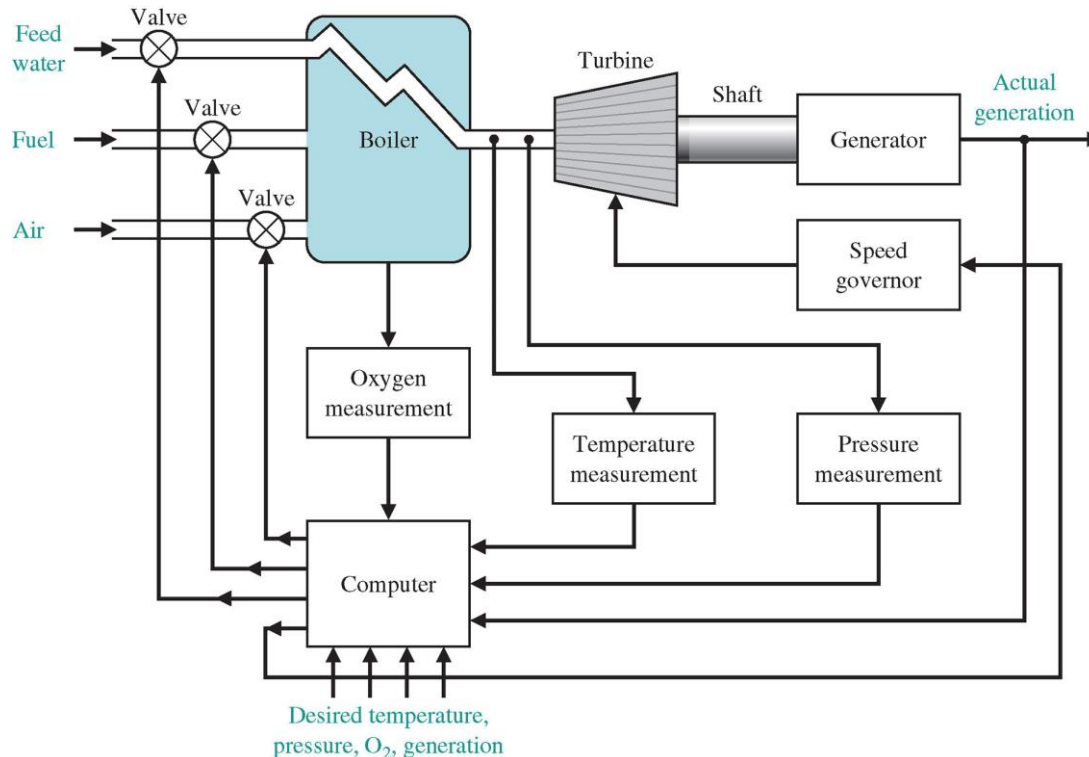
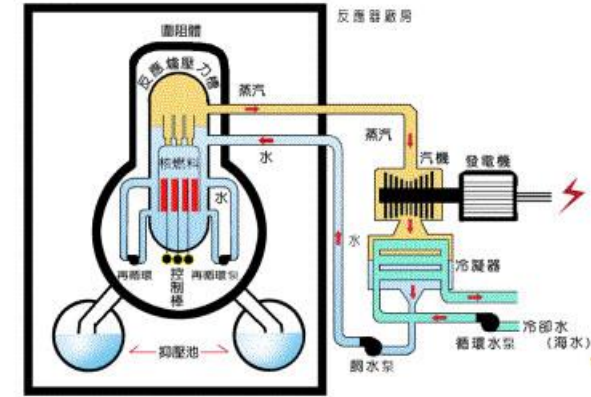


UMot 3-Axis XYZ Table Gantry Robot
<https://www.youtube.com/watch?v=CJtDBQ8aQwQ>

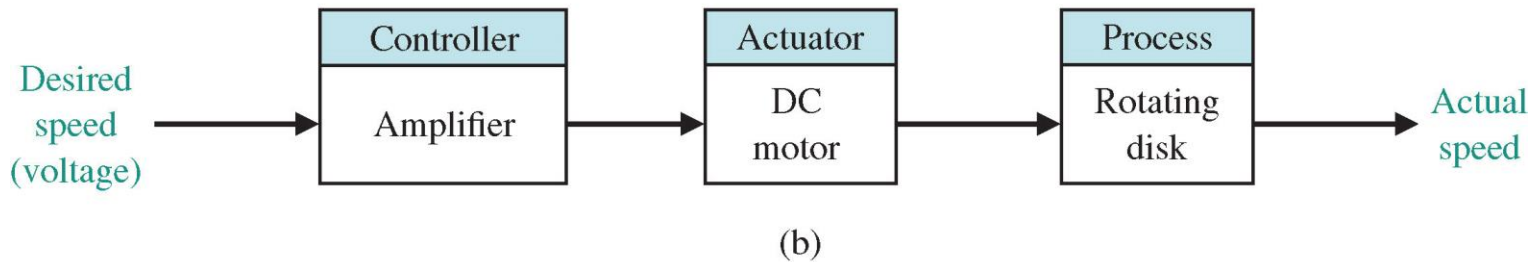
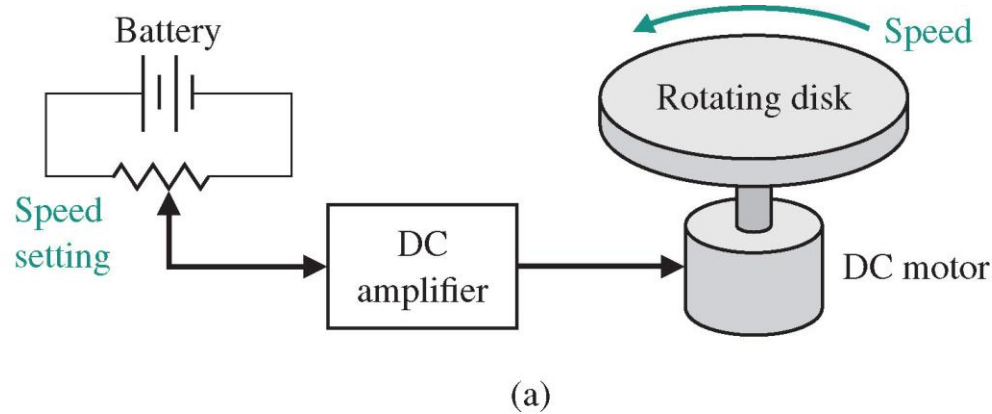
Coordinated Control System for a Boiler-Generator



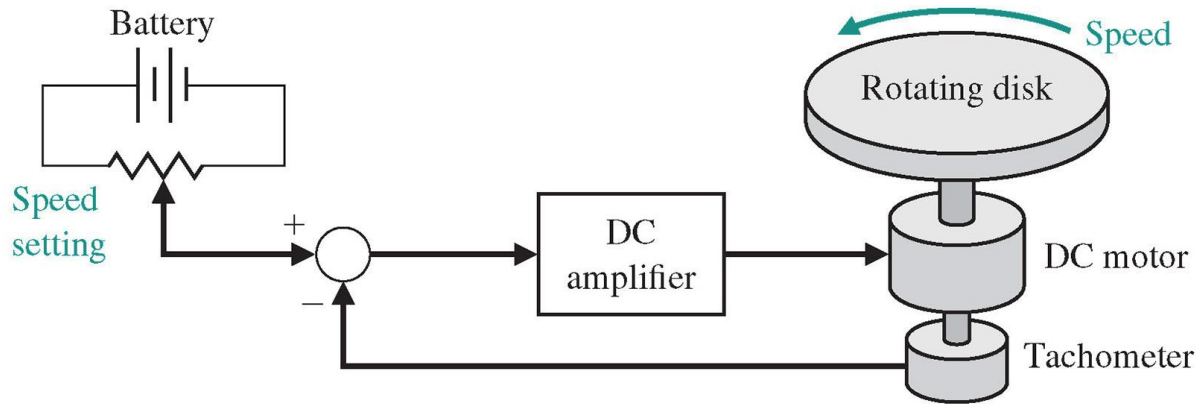
沸水式電廠流程



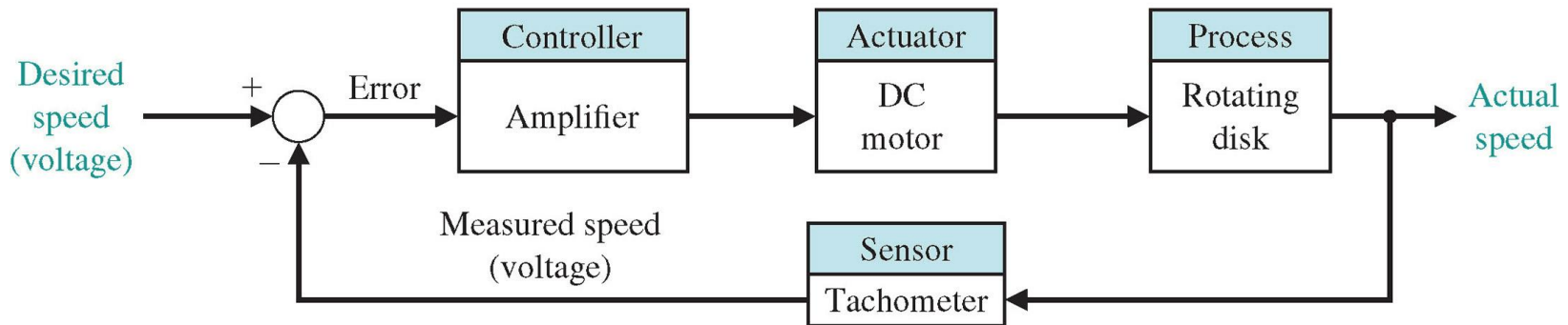
- **Open-Loop Control** of the Speed of a Rotating Disk
- **(Without Feedback)**



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

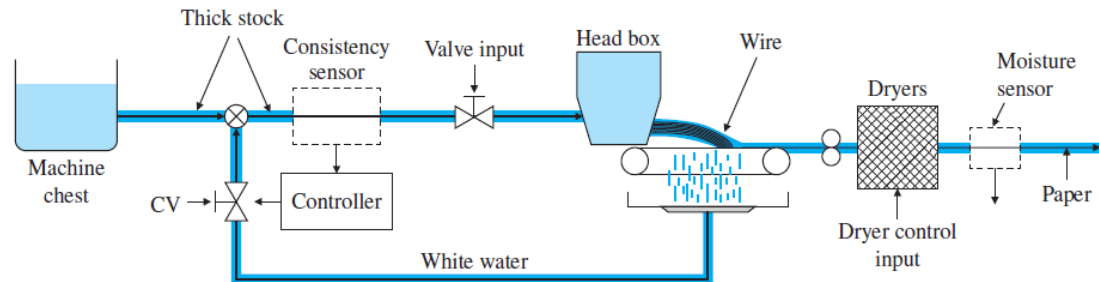
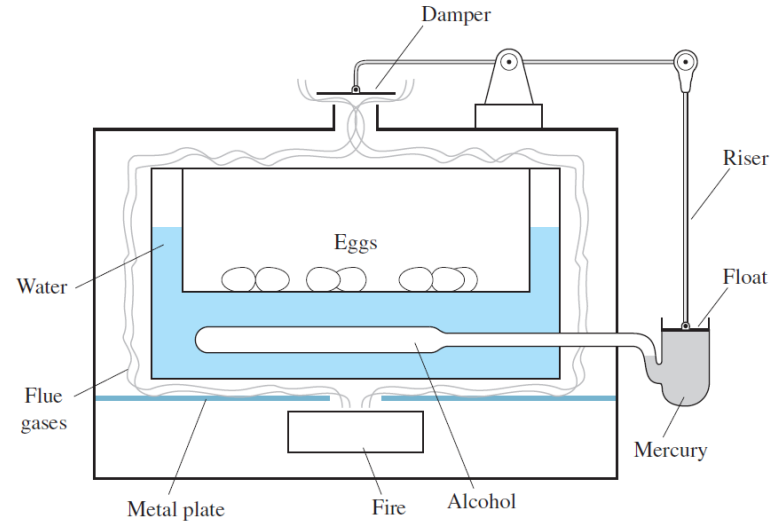


(a)

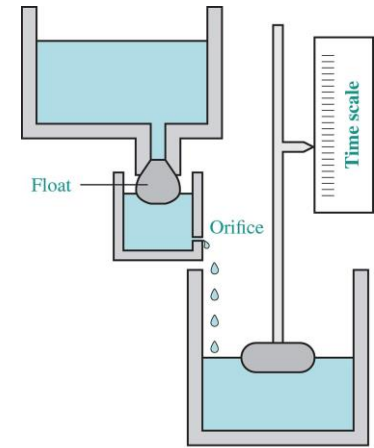


(b)

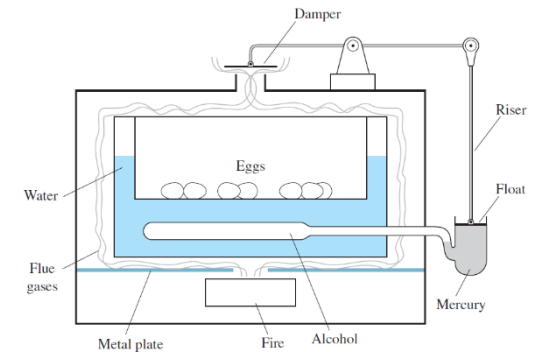
- Drebber's incubator for hatching chicken eggs
- A papermaking machine



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



- 1620 **Cornelis Drebbel, Holland**
First feedback system
Temperature regulator



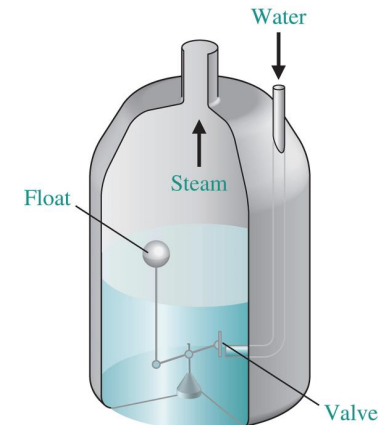
- 1462-1727 **Sir Isaac Newton**
Mathematical modeling



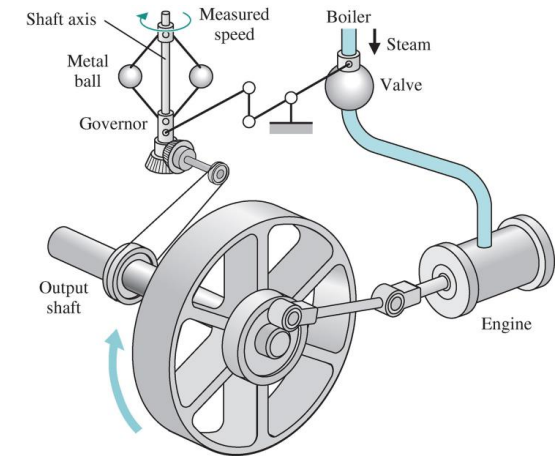
- 1685-1731 **Brook Taylor**
Taylor series







- 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