Spring 2020

控制系統
Control Systems

Unit 13
A Brief History of Feedback and Control

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NTU-EE

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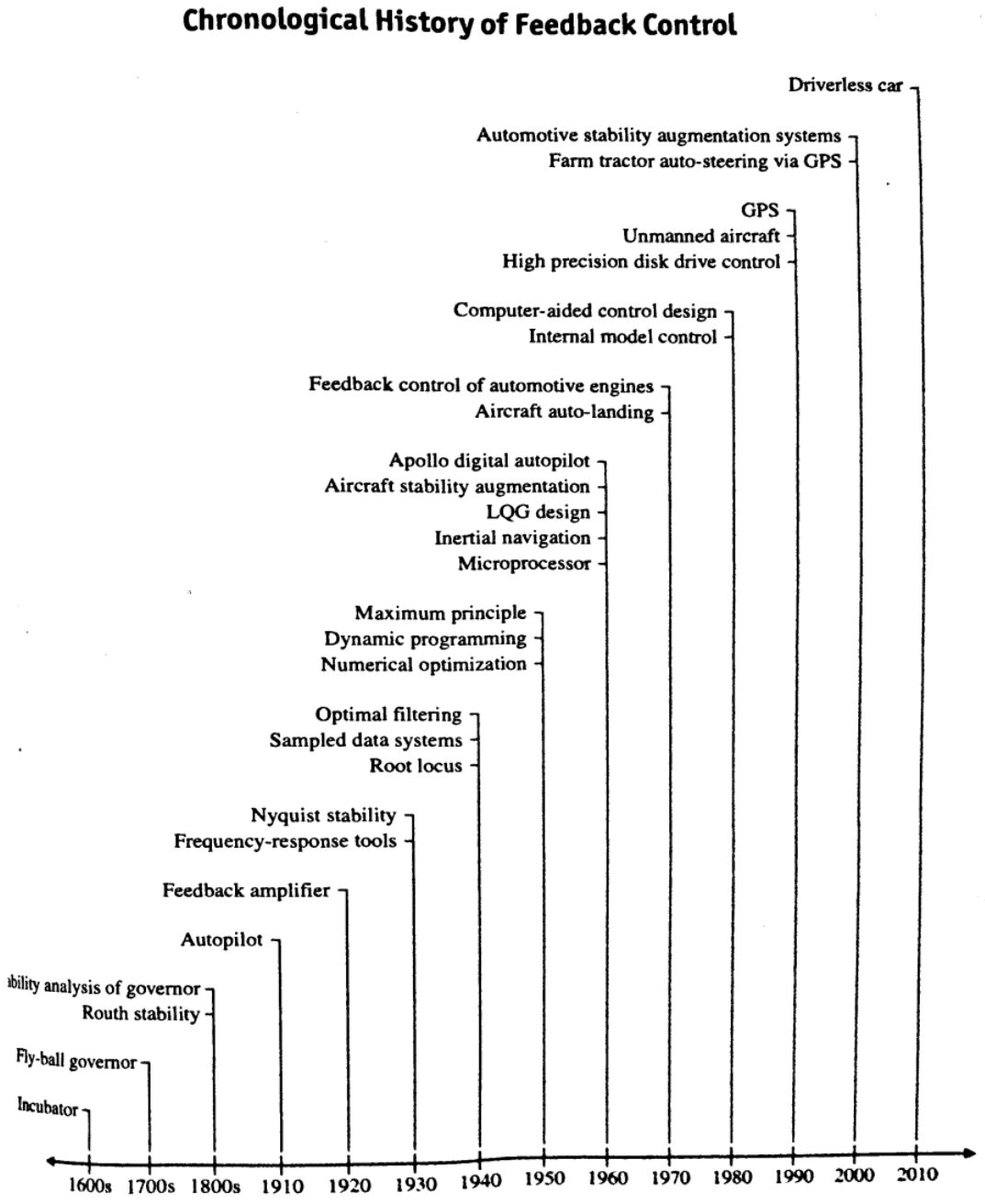
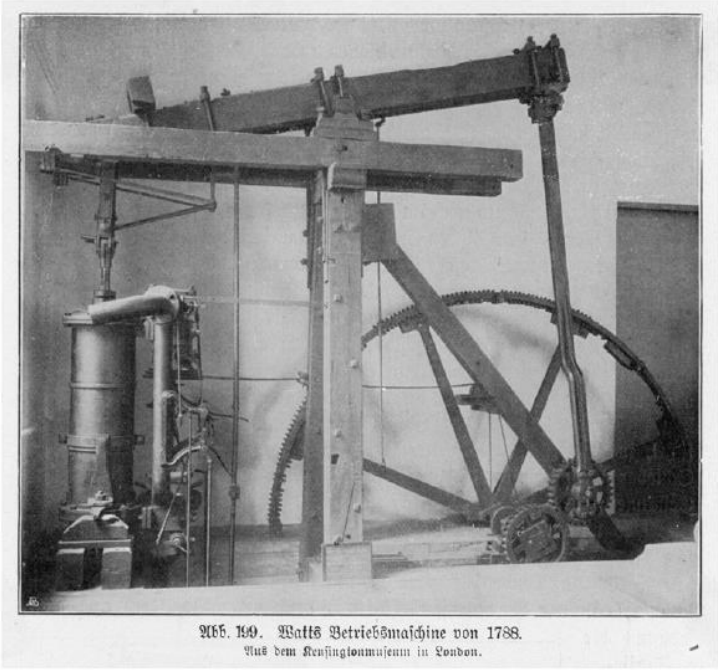
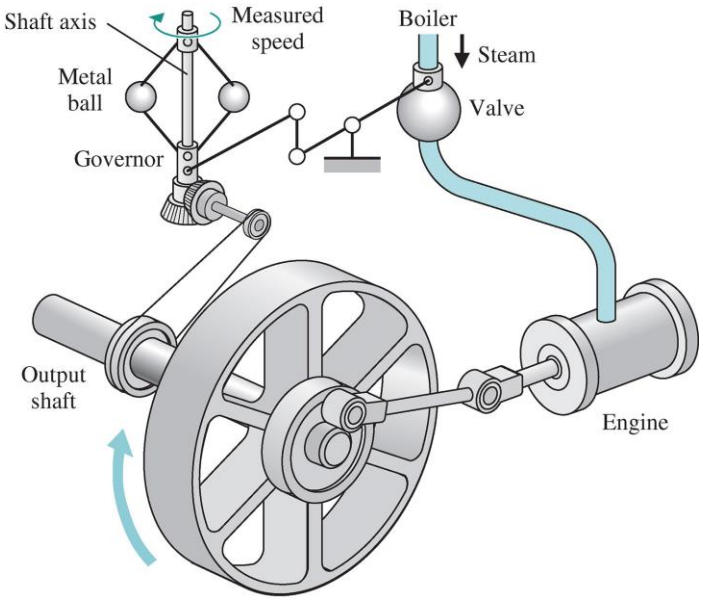
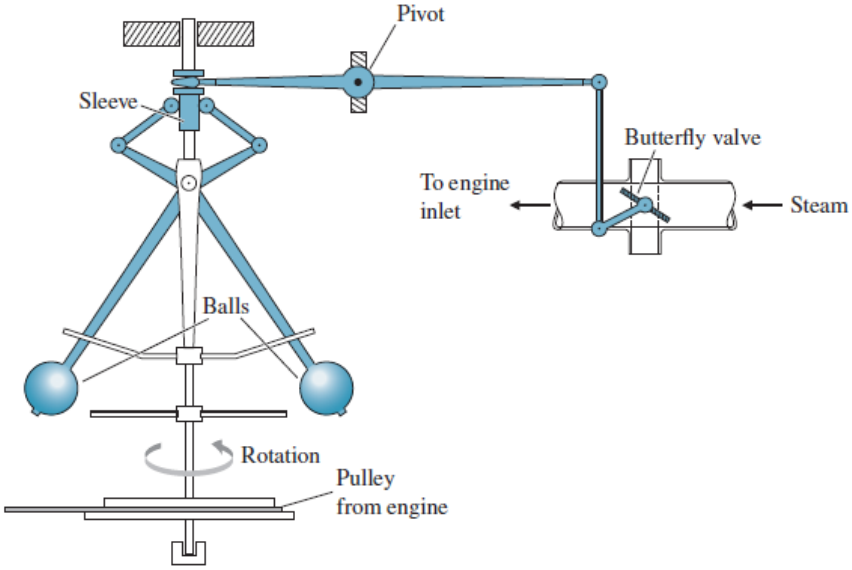
Chronological History of Feedback Control



Flour Mill and Fly-Ball Governor

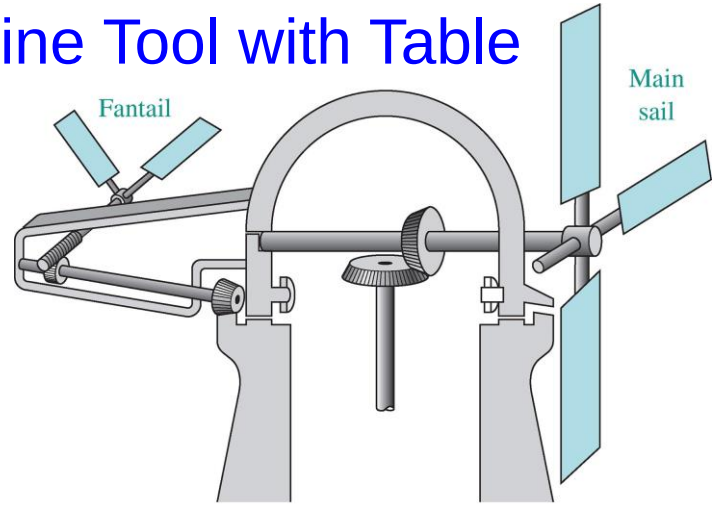


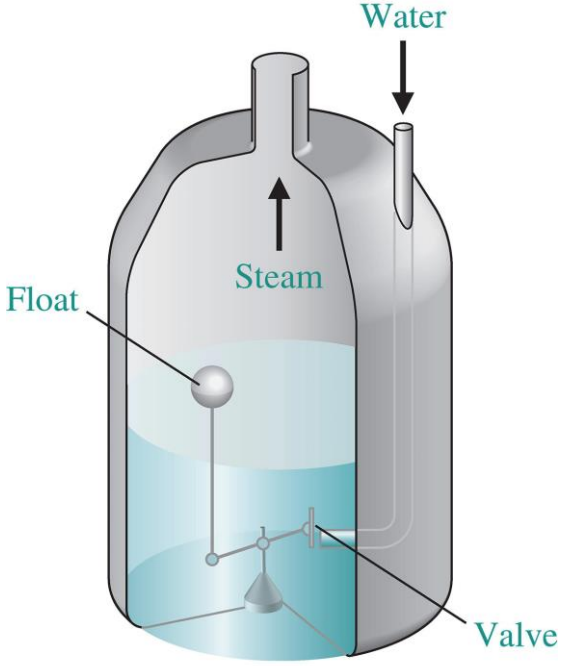


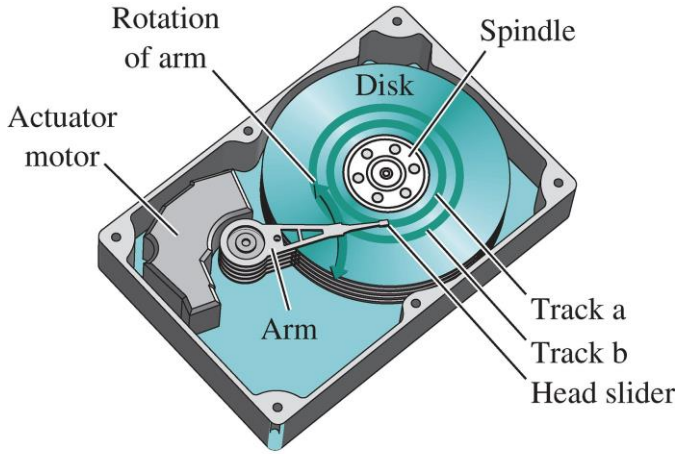


Machines with Automatic Control Features

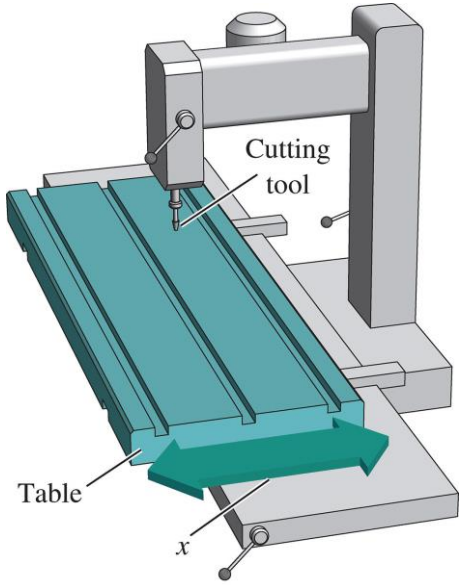
- Water-Level Float Regulator
- Automatic Turning Gear for Windmills
- Disk Drive
- Machine Tool with Table





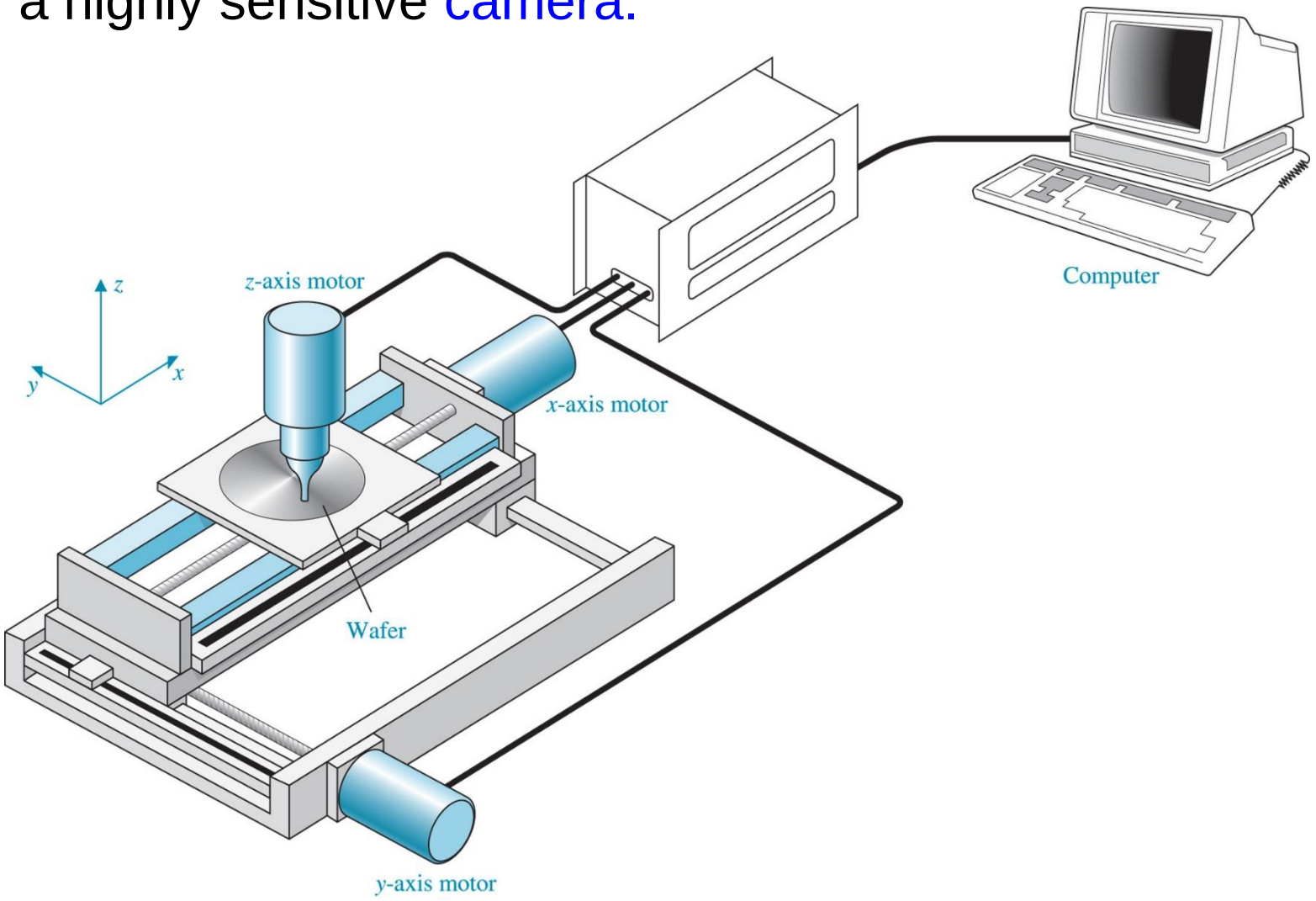


(b)

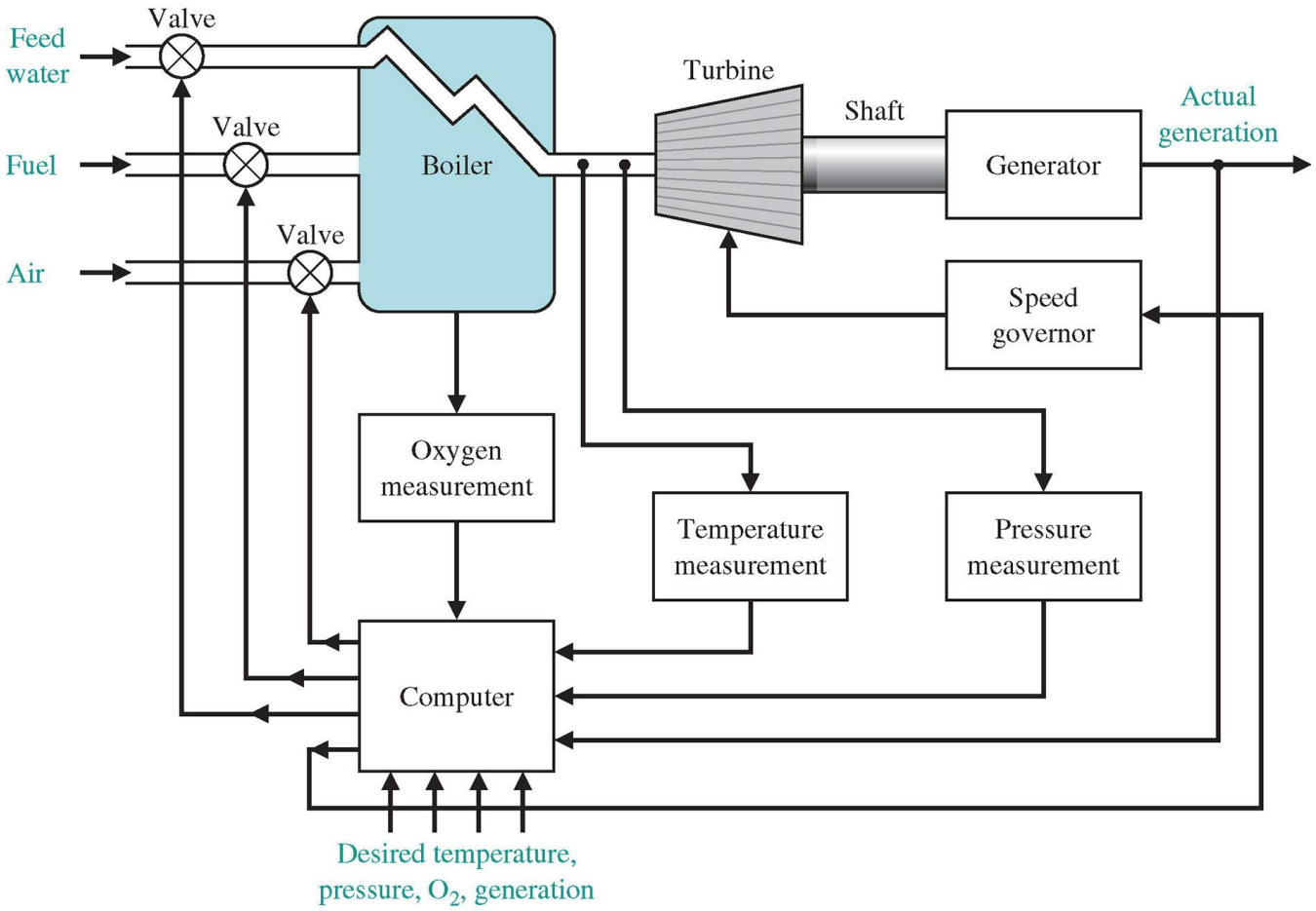


Machines with Automatic Control Features

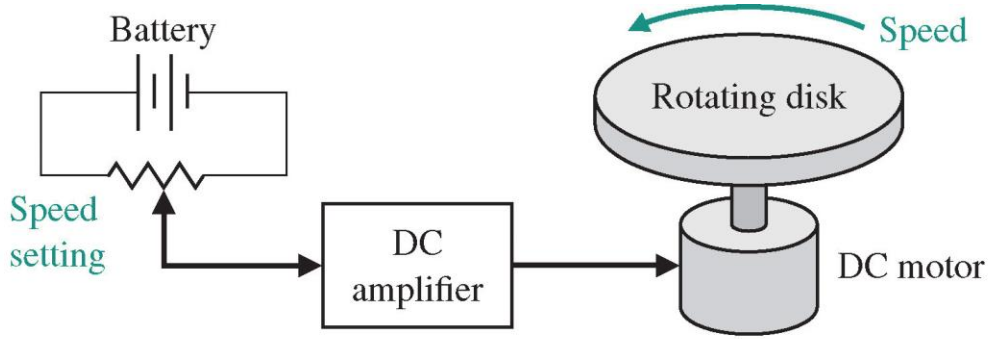
- A three-axis control system for inspecting individual semiconductor wafers with a highly sensitive camera.



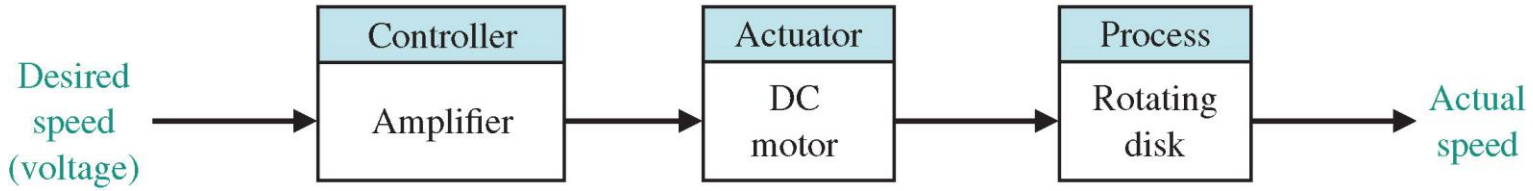
- Coordinated Control System for a Boiler–Generator



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

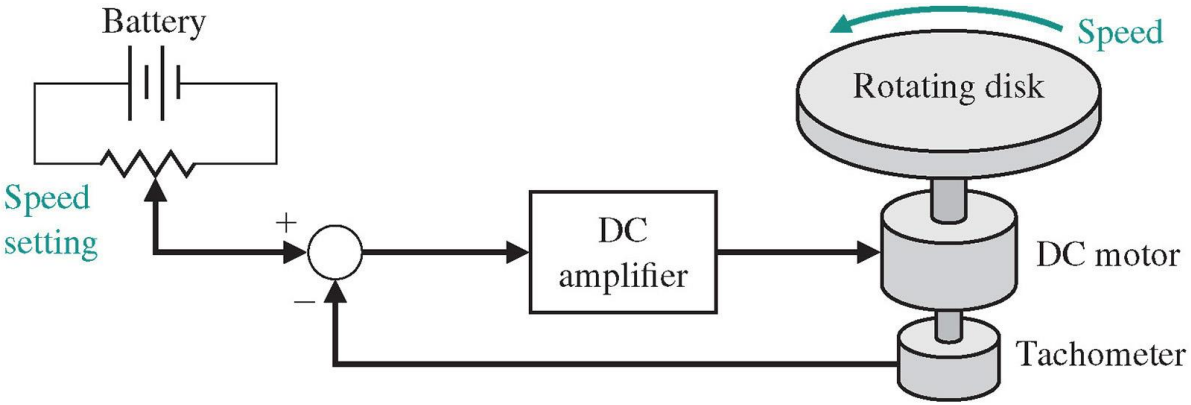


(a)

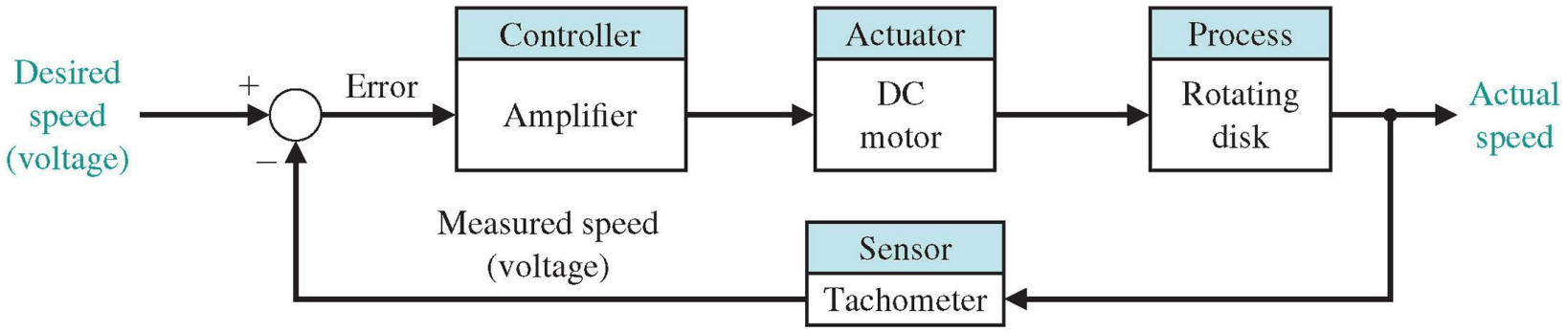


(b)

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



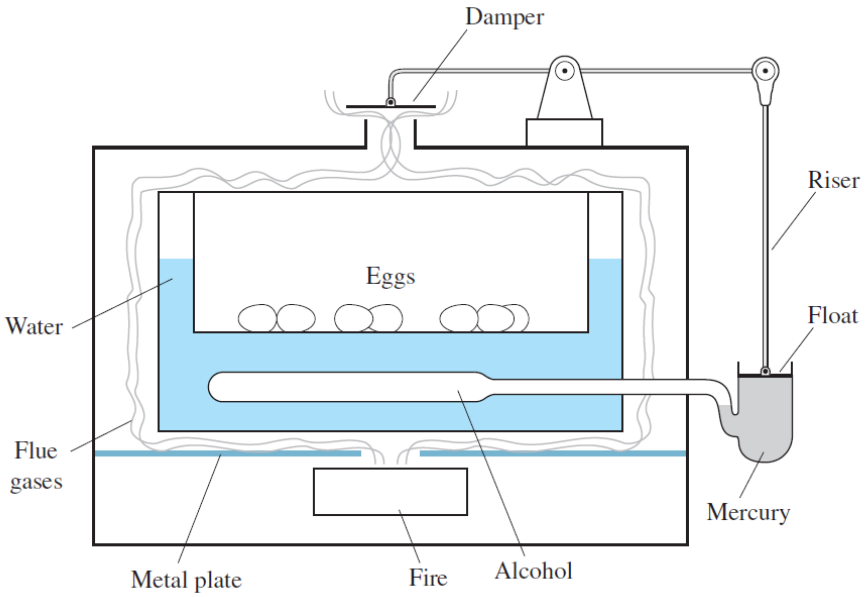
(a)

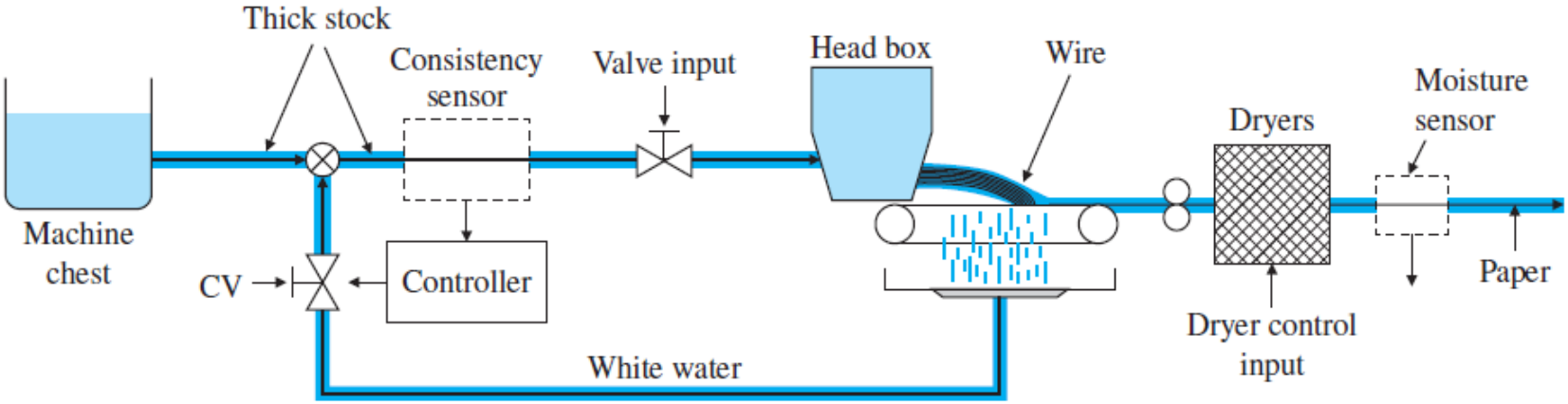


(b)

Automatic Turning Gear for Windmills

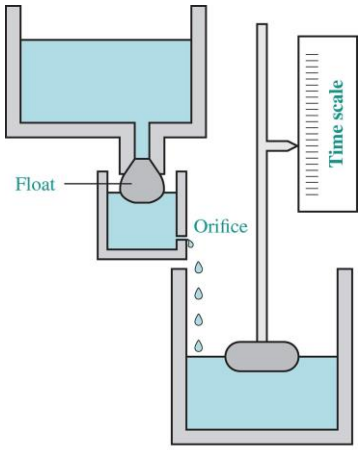
- Drebbel's incubator for hatching chicken eggs
- A papermaking machine





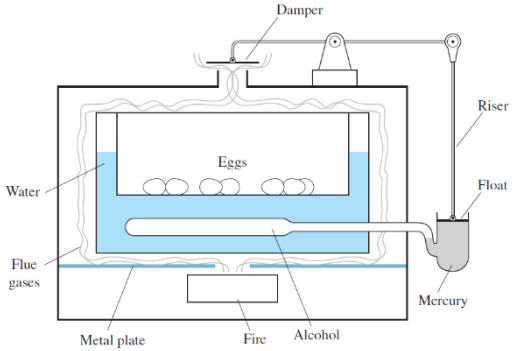
Brief History of Feedback Control

- B.C.200 Greece
  Float regulator mechanism



- B.C.50 Middle East
  Water clock

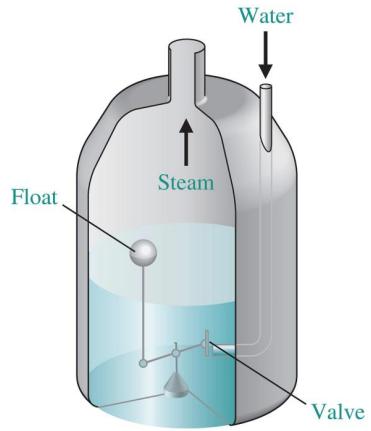
- 1620 Cornelis Drebbel, Holland
  First feedback system
  Temperature regulator



- 1462-1727 Sir Isaac Newton
  Mathematical modeling

- 1685-1731 Brook Taylor
  Taylor eries

- 1700 Dennis Papin
  Pressure regulator for steam boiler



Brief History of Feedback Control

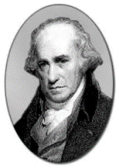
- 1749-1827 Pierse Simon Laplace

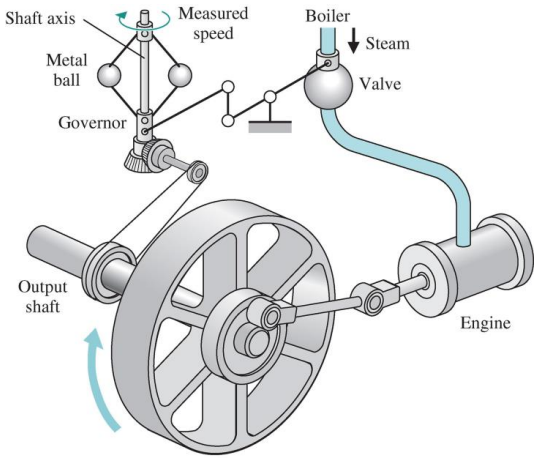
  Laplace Transform

- 1769-88 James Watt

  First automatic controller

  Flyball governer





- 1765 I. Polzunov, Soviet Union

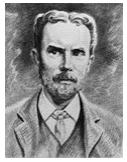
  First level regulator system

- 1831-1907 Edward John Routh

  Routh criterion

- 1859-1925 Oliver Heaviside

  Mathematical analysis



- 1868 James Clerk Maxwell

  Mathematical theory for control system

Brief History of Feedback Control

- 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

Brief History of Feedback Control

- 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

Brief History of Feedback Control

- 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