# AUTOMATIC CONTROL SYSTEMS

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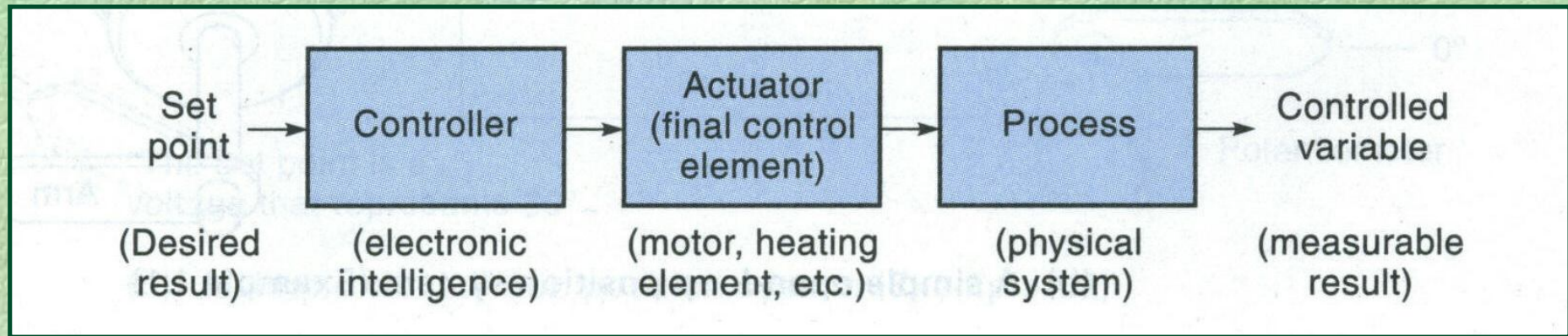# Lecture 12

## Introduction to Industrial Control Systems

*Topics to be covered include:*

❖ Distinguish between open-loop and closed-loop control systems.

❖ Analog and digital control systems.

❖ How process control systems work.

# Control Systems

❖ Control System: A collection of components working together under the direction of some intelligence.

❖ Classifications of control systems:

◆ Regulatory System

• Maintains a parameter at or near a set point.

◆ Follow-up System

• Causes the output to follow a predefined path.

◆ Event Control System

• Controls a sequential series of events.

# Open-Loop Control



Set point (Desired result) → Controller (electronic intelligence) → Actuator (final control element) (motor, heating element, etc.) → Process (physical system) → Controlled variable (measurable result)

❖ Controller independently calculates the exact input required for the set point without sensing the process.

❖ Controller never knows the effect of the actuator on the process.

❖ Appropriate where actuator actions are very repeatable and reliable.

# Open-Loop Control
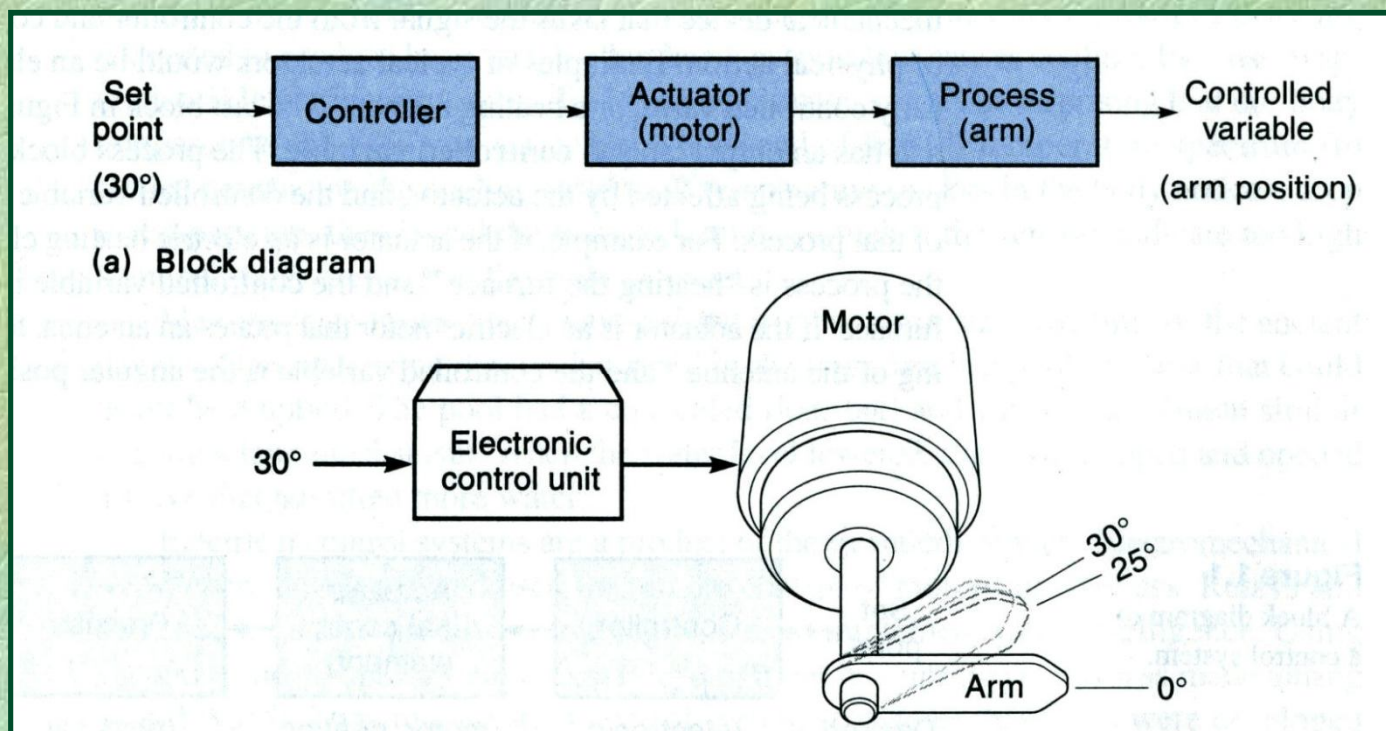


The motor rotates at a reliable speed, such as 5 degrees/second. Based on that, reliable positioning can be performed.
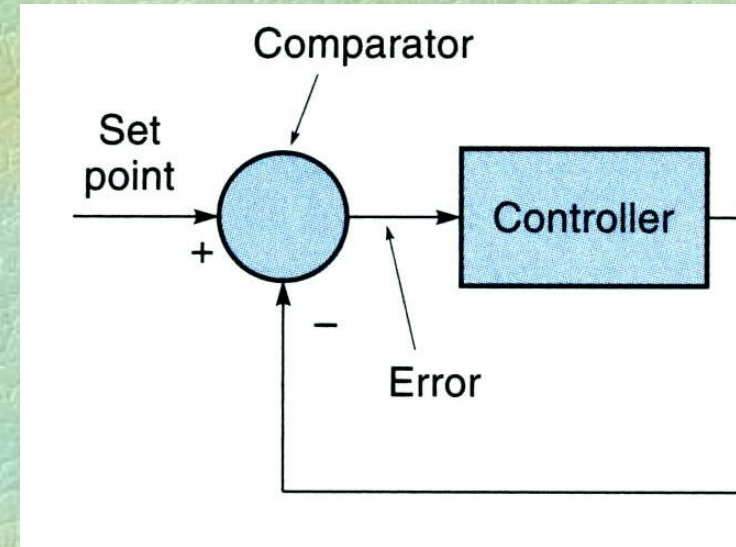
# Closed-Loop Control
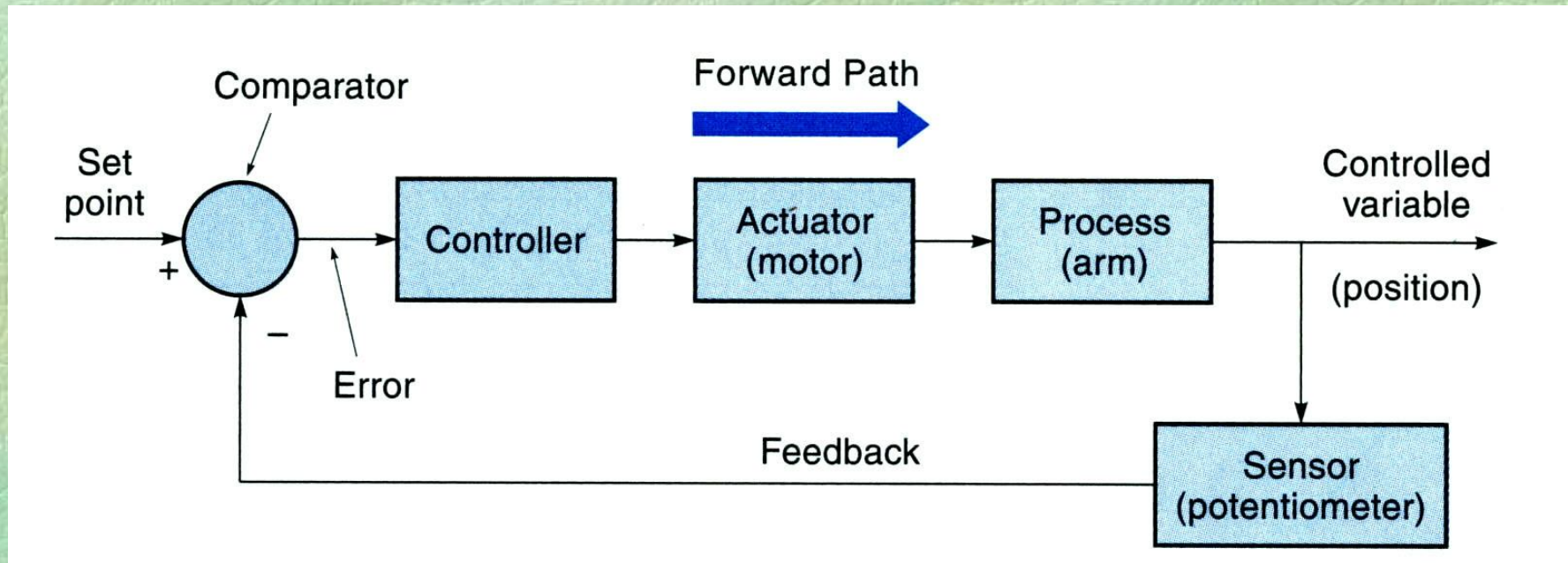


❖ The output process is monitored by a sensor providing feedback, allowing the controller to make adjustments to the actuator.
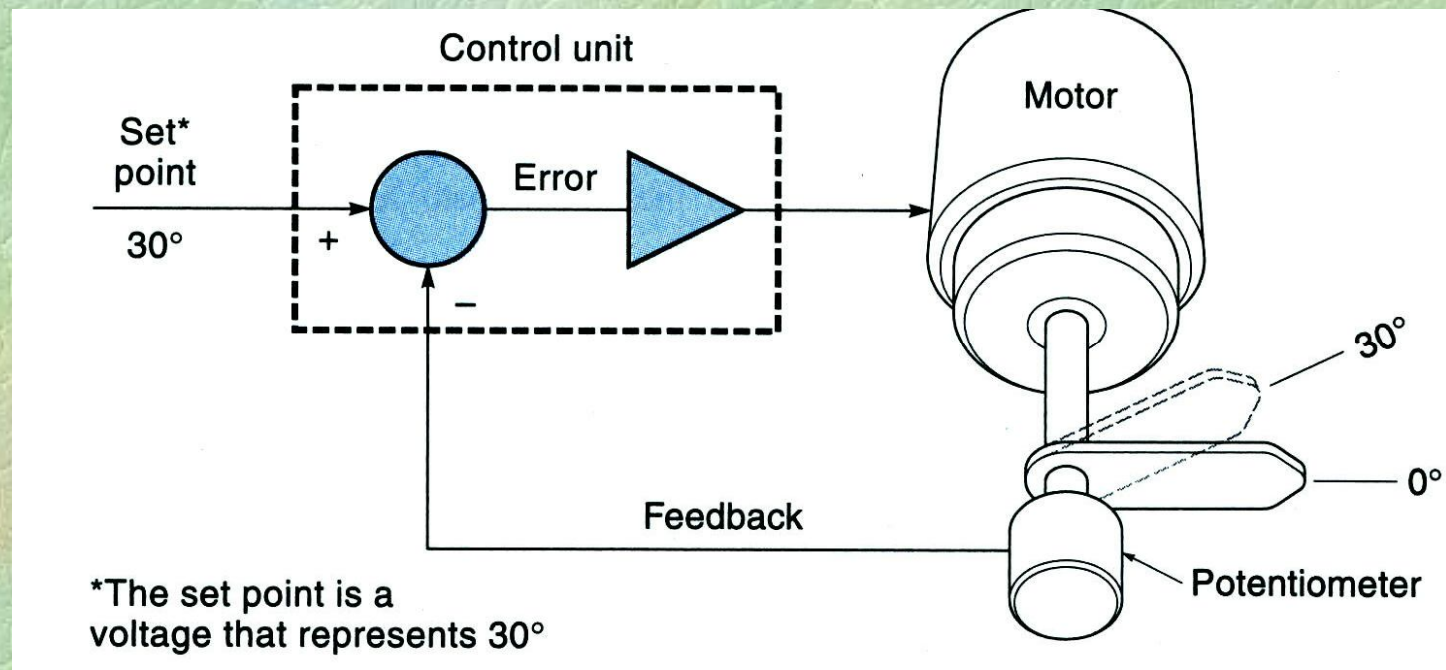
# Closed-Loop Control

❖ The comparator compares the set point to the actual and produces an error.

Error = Set point – Actual



❖ The controller works to minimize the error signal.

❖ Zero error indicates actual = set point.

# Closed-Loop Control



- The difference in the actual and setpoint produce an error, which the controller responds too.
- Control strategies can be simple or complex as how to minimize the error.
- Closed-loop is preferable to open-loop because ……

# Different Types of Control Systems

## Analog Control Systems

❖ In an analog control system, the controller consists of traditional analog devices and circuits – linear amplifiers.

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❖ Analog control provides instantaneous changes.

## Digital Control Systems

❖ In digital control systems, the controller is often a microprocessor or microcontroller.

❖ The controller repeats a program over and over. Each repetition is an iteration or scan.

❖ The required scan time is dependent on the process being controlled.

# Analog and Digital Control System



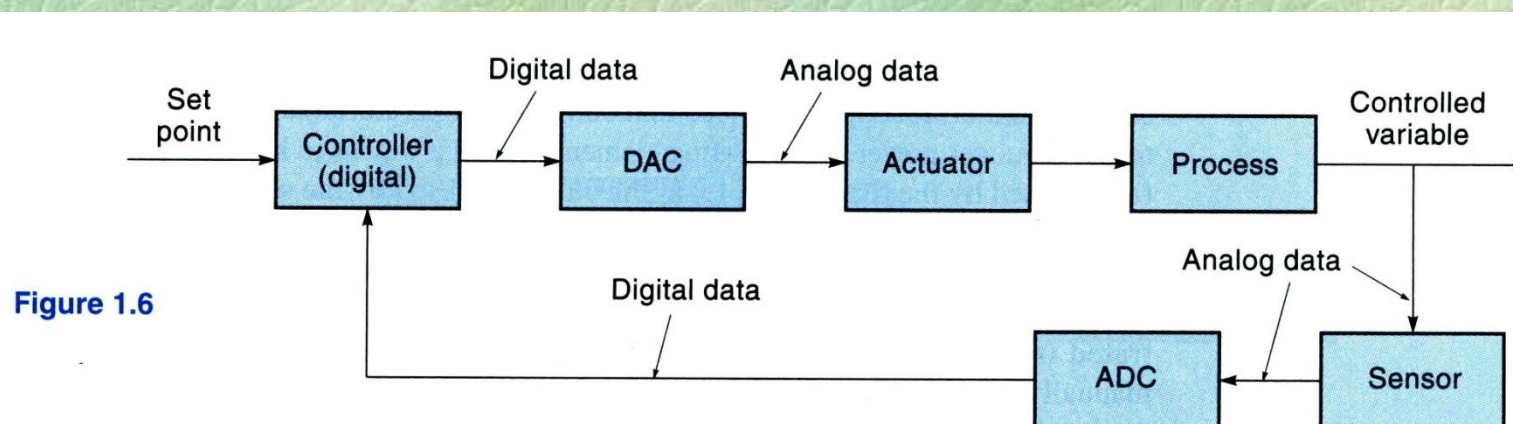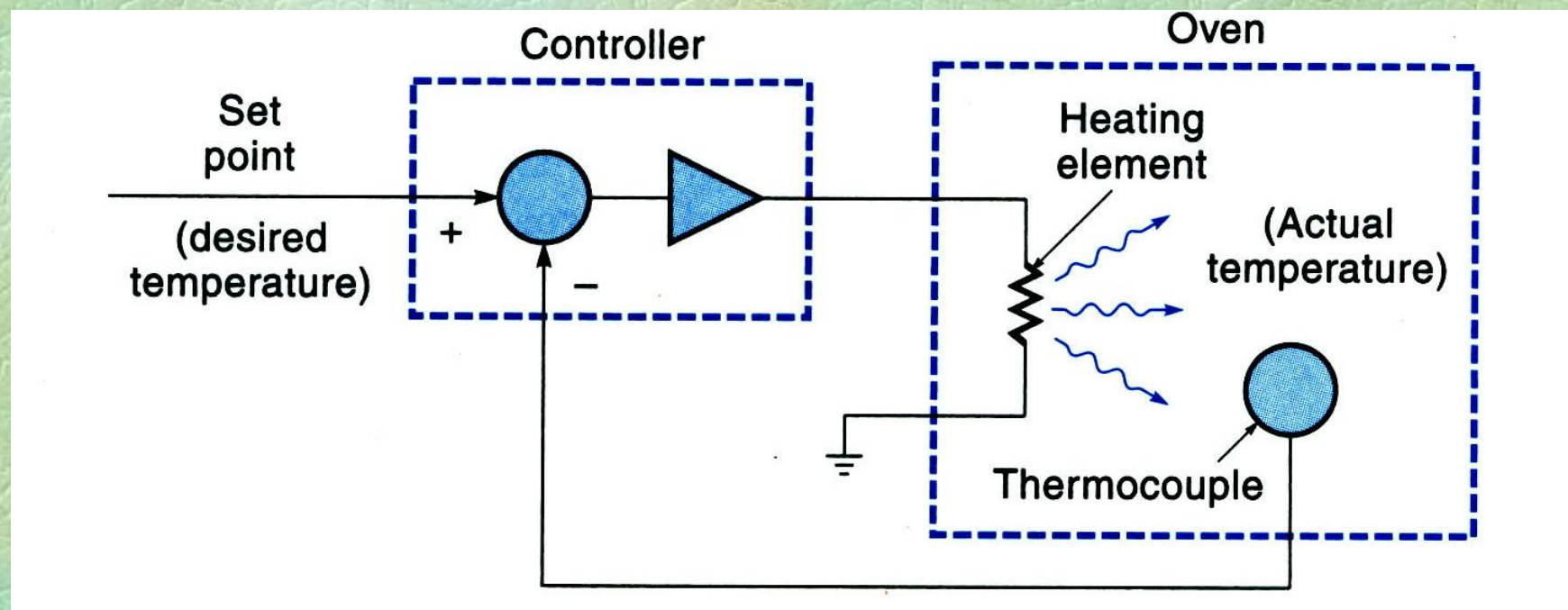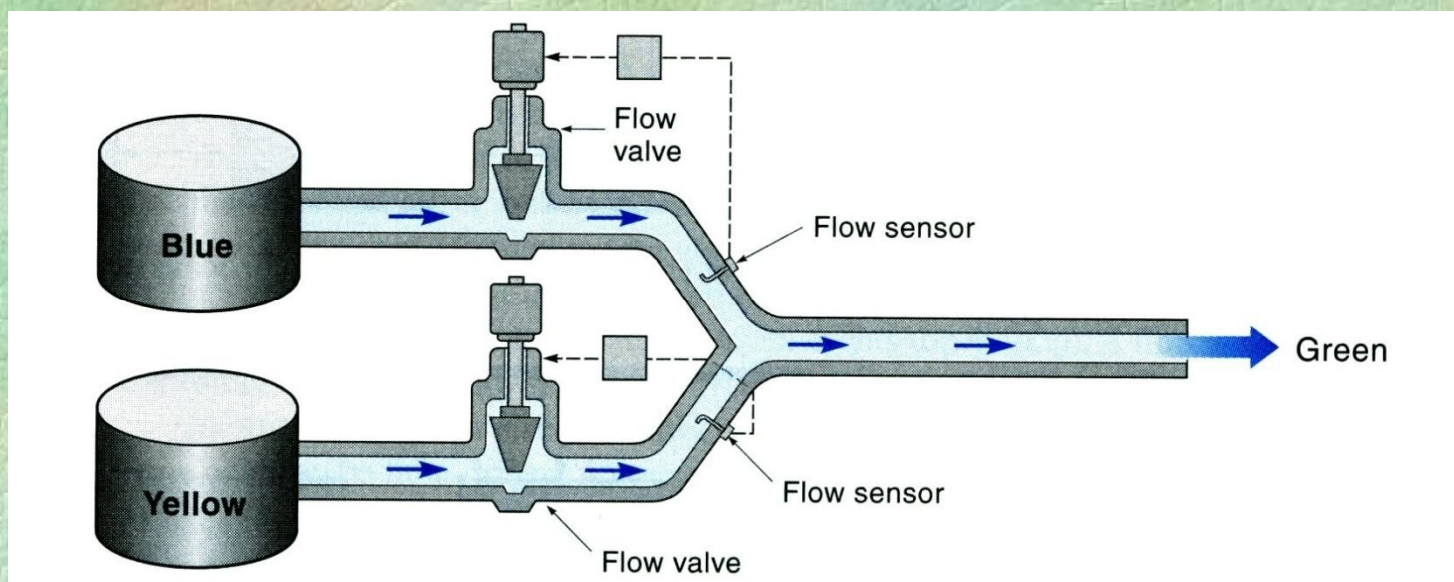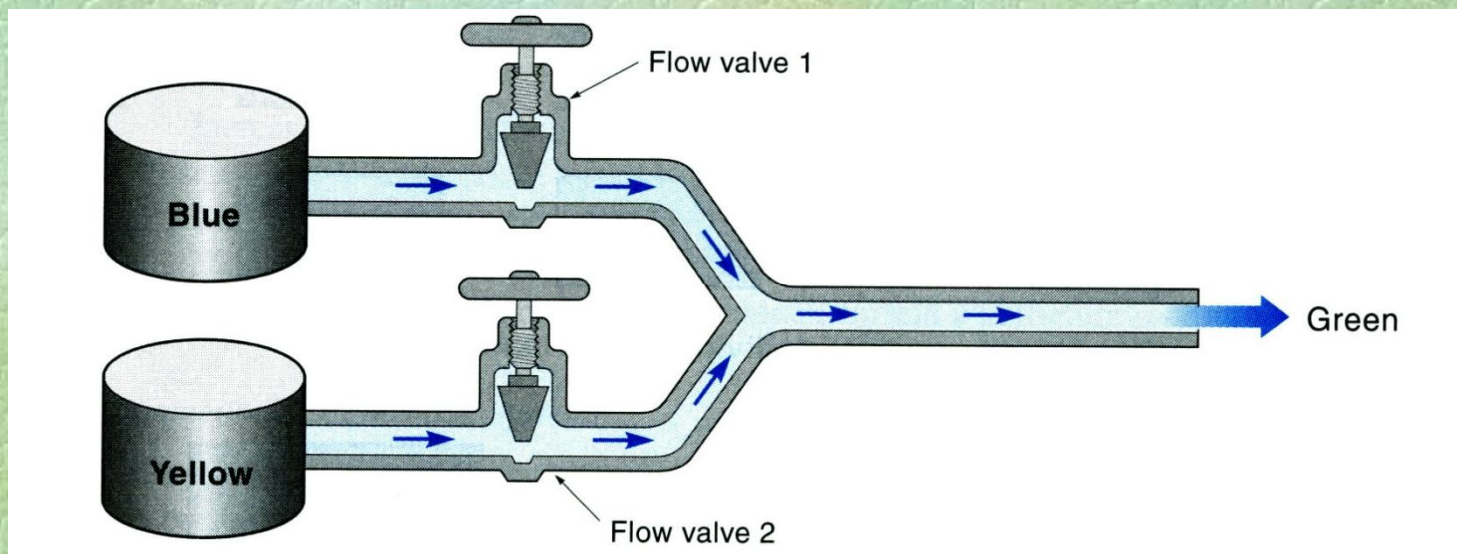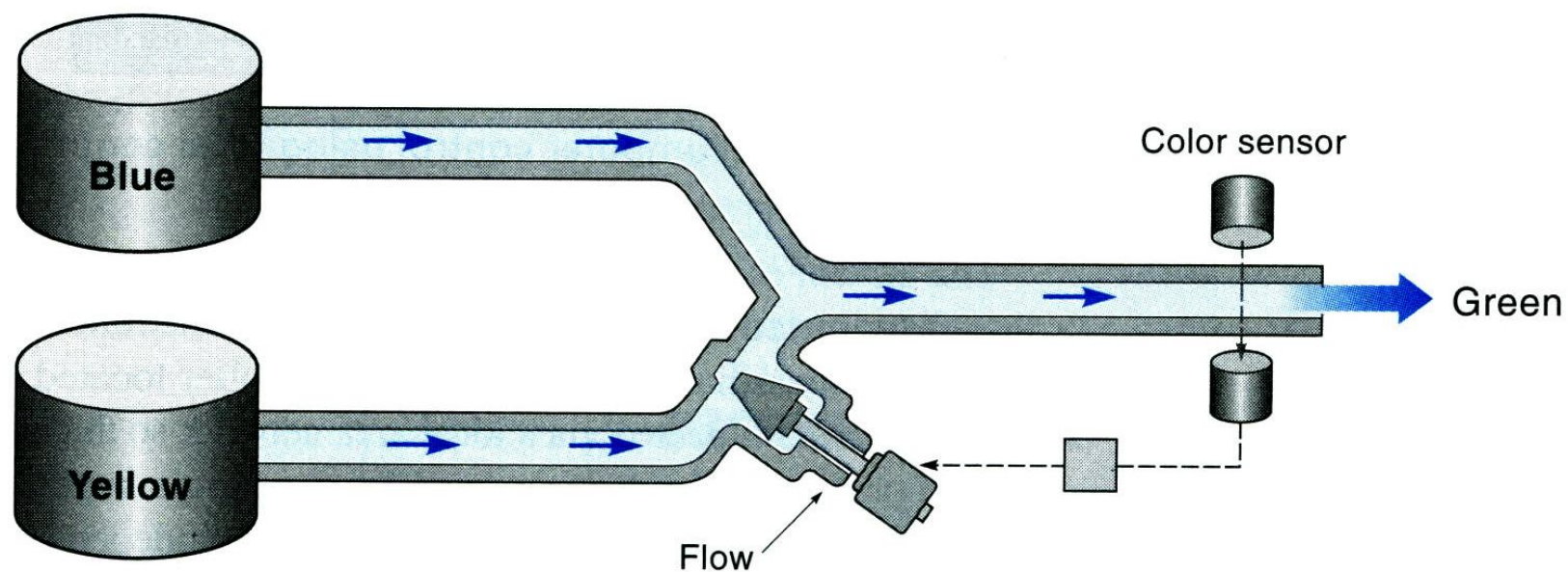Figure 1.6

# Manual Control Versus Automatic Control
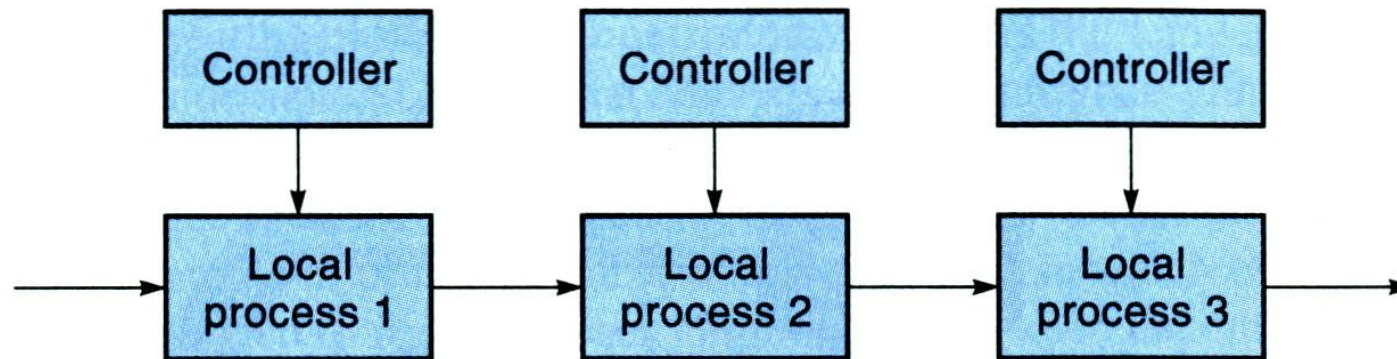
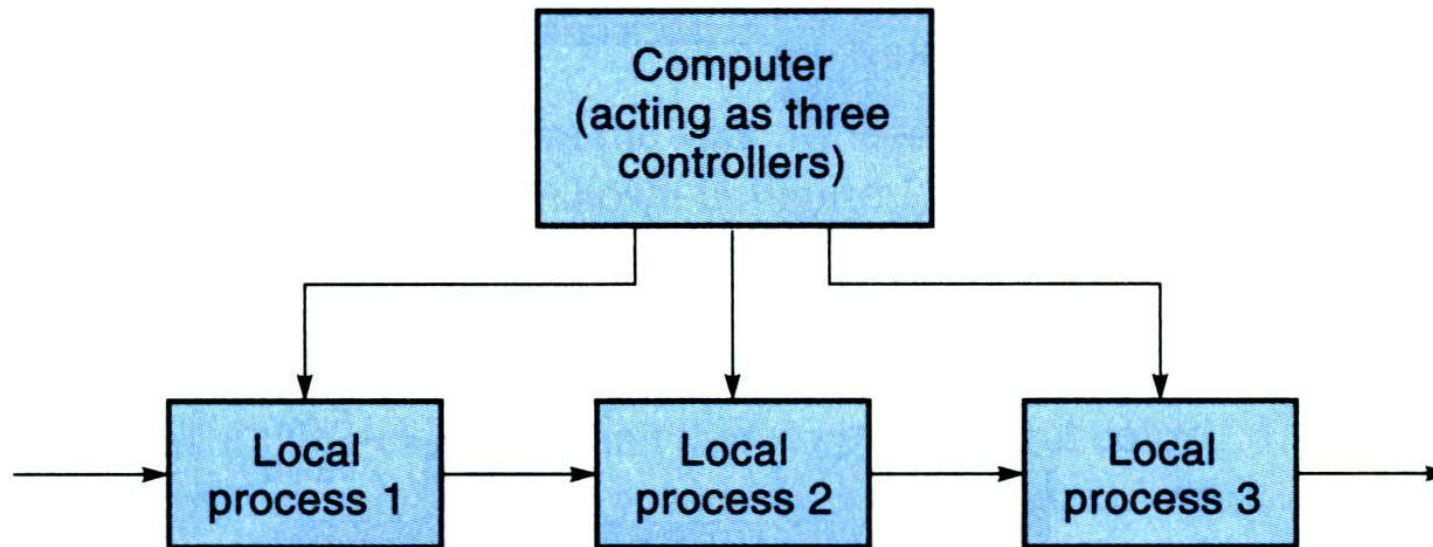# Automatic Color Control



(c)  Automatic color control

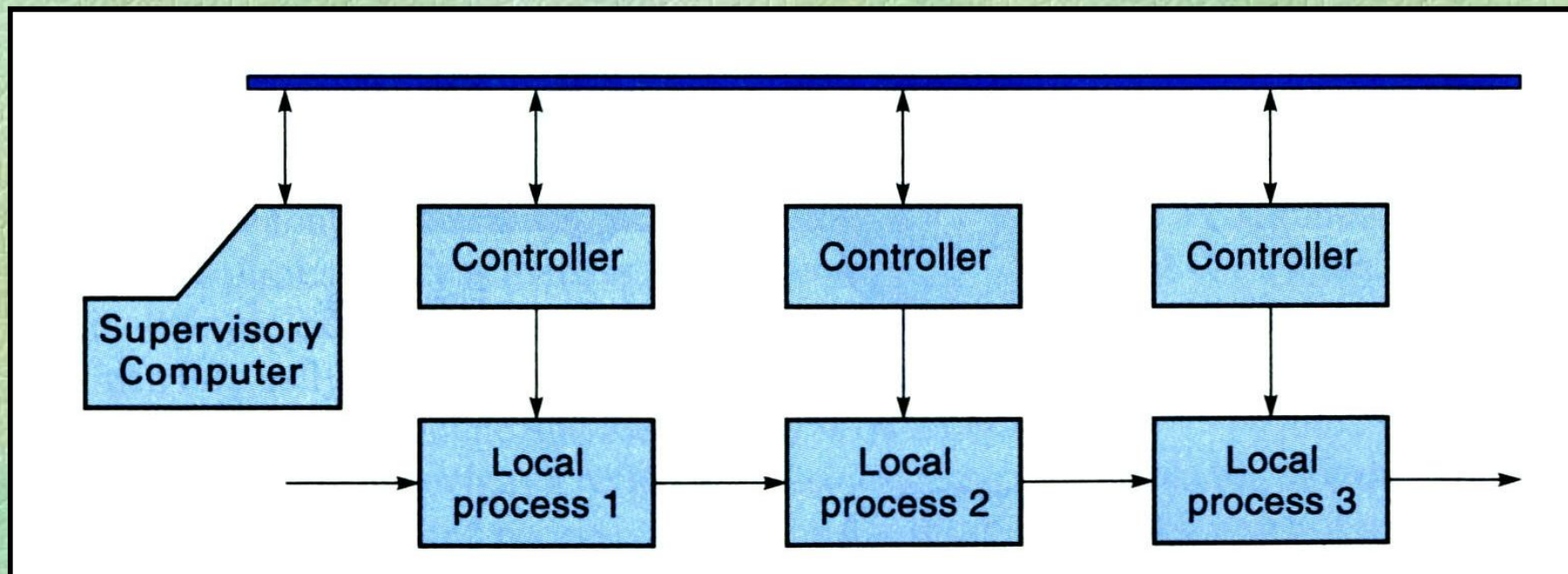# Individual Local Control



(a) Individual local controllers

❖ For a process "flow", if the line needs to adjusted, each independent controller needs to be adjusted.

# Direct Computer Control



❖ Advantage: Local processes can be monitored and adjusted.

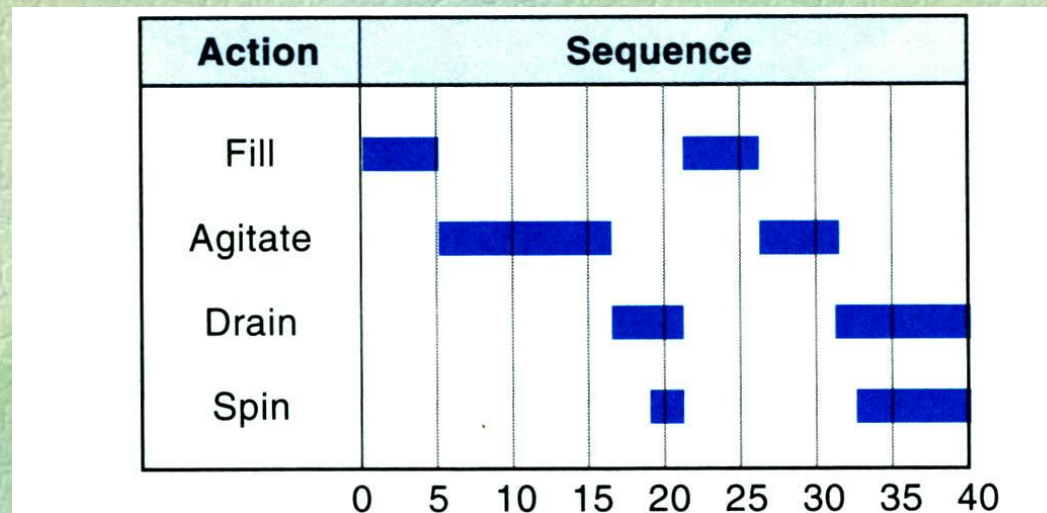❖ Disadvantage: If controller goes down, line is down.

# Distributed Control



❖ Best of both worlds: Each process is independent, but supervised from a central location.

# Sequentially Controlled Systems

❖ Time-Driven

 ◆ Each operation in the sequence is performed for a certain amount of time. May be open-loop control.



❖ Event-Drive:

 ◆ Each operation is performed until some event goal is reached. Must be closed-loop control.

# Numerical Control (NC)

❖ Numerical Control (NC): type of digital control on machine tools which use a numeric coordinate system to define the movement of components, typically in X, Y, Z coordinates.



❖ Today's systems can accept data directly from CAD drawing information for the control of the operation. Computer-aided Manufacturing (CAM).
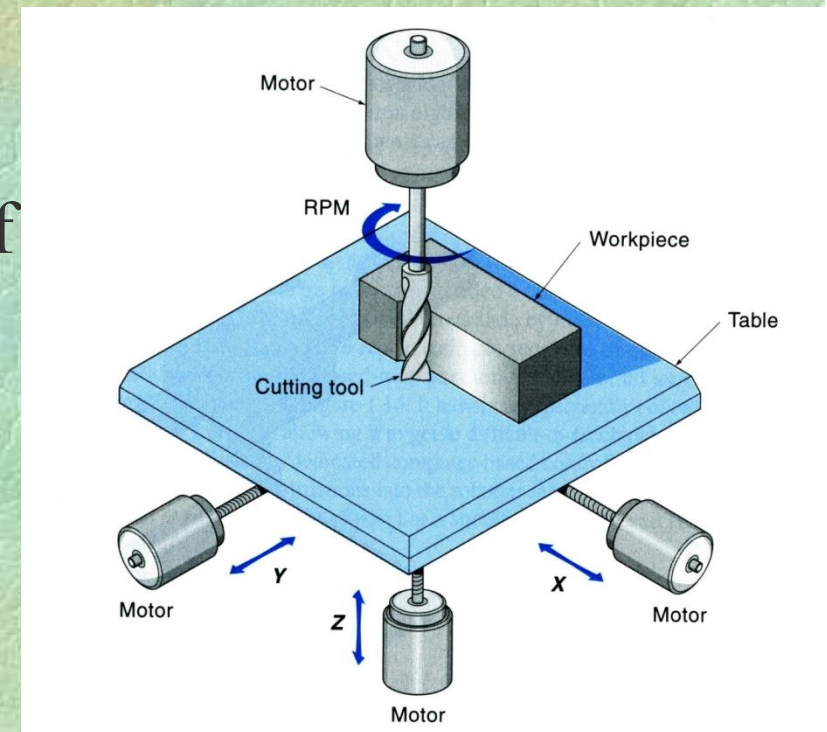
# Robotics

❖ Robotics: Industrial control robotics are classic examples of position control systems for manufacturing.

❖ Pick-and-place robots, the simplest type, pick up parts and place them nearby, such as onto a printed circuit board.