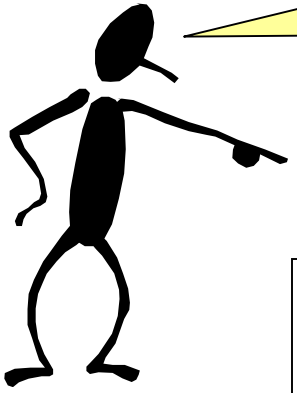
CHAPTER 1 : INTRODUCTION TO PROCESS CONTROL



When I complete this chapter, I want to be able to do the following.

- **Explain the feedback concept applied to control**
- **Explain and identify the three elements in a feedback loop**
- **Be able to apply feedback manually to many chemical process examples**

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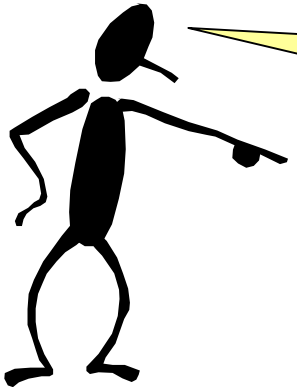
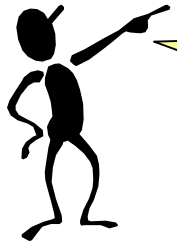


Outline of the lesson.

- **Why Process Control and Why Now?**
- **Basic Questions about Control**
  - **What does a feedback system do?**
  - **Why is control necessary?**
  - **Why is control possible?**
  - **Where is control done?**
  - **How is control documented?**
- **Workshop**
- **Self-Study Guides**

WHY HAVE A PROCESS CONTROL COURSE?

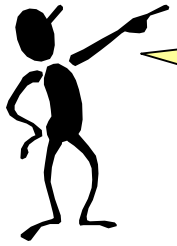
- When I run a kinetics experiment, how do I maintain the temperature and level at desired values?
- How do I manufacture products with consistently high quality when raw material properties change?
- How much time do I have to respond to a dangerous situation?



Every engineer needs basic knowledge about control. Many exciting career opportunities exist for a technical specialist.

WHY NOW FOR THE CONTROL COURSE?

- **We started with steady-state analysis because it is easier and important.**
- **We are building expertise in fundamentals (fluids, heat transfer, thermo, etc.) and process units (distillation, CSTR, etc.). Now we have examples that need control!**
- **We need to master control before integrating our knowledge in process design?**



It's a perfect time to learn how to "drive" the chemical process. With this insight, we will be able to design plants that can be controlled safely and produce high quality products.

WHAT DOES A FEEDBACK SYSTEM DO?

Let's look at a few examples first. Then, we will develop a general concept.

- **Describe your method for driving a car.**
- **Could you drive a car without looking out the windshield?**
- **What must be provided by the car designer?**
- **Can a "good design" eliminate the need to steer?**

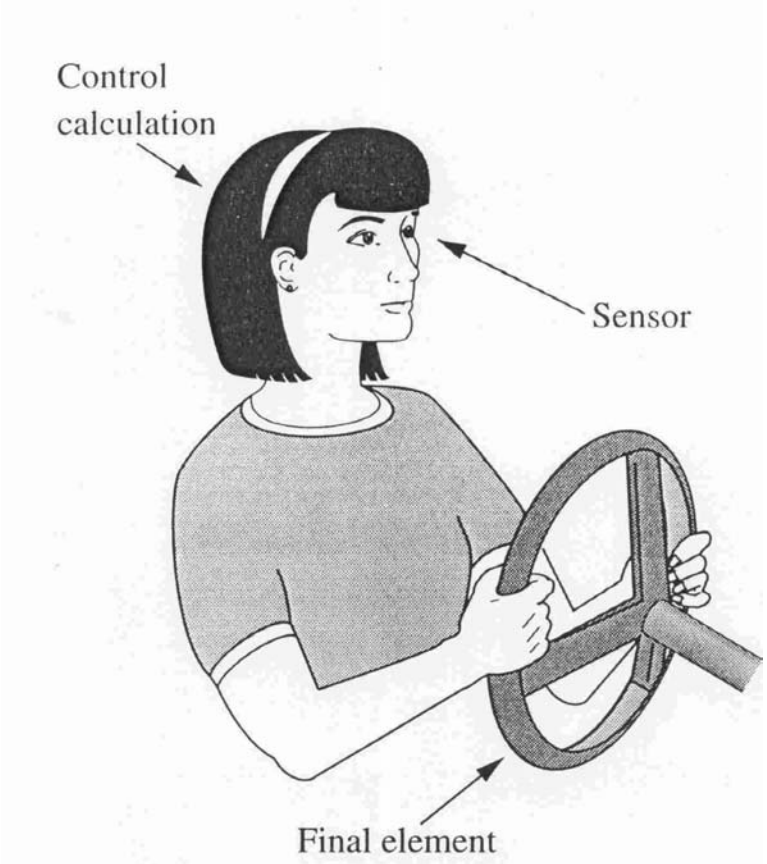


FIGURE 1.1

WHAT DOES A FEEDBACK SYSTEM DO?

Let's look at a few examples first. Then, we will develop a general concept.

- **Describe how home heating works.**
- **Describe the dynamic behavior of T.**
- **What must be provided by the house designer?**
- **Can a "good design" eliminate the need to change the heating?**

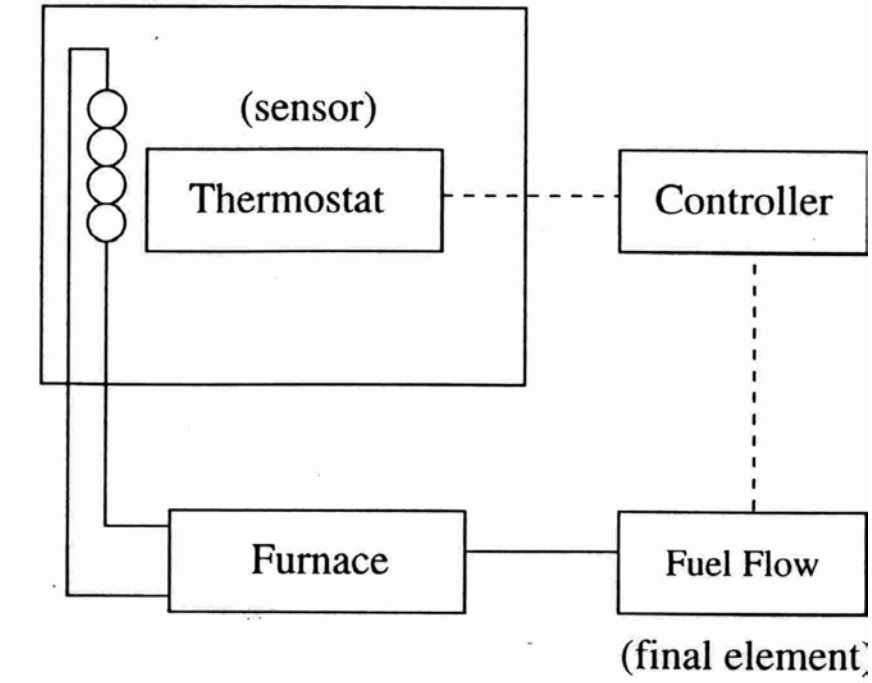


FIGURE 1.2

WHAT DOES A FEEDBACK SYSTEM DO?

Why does the temperature cycle?

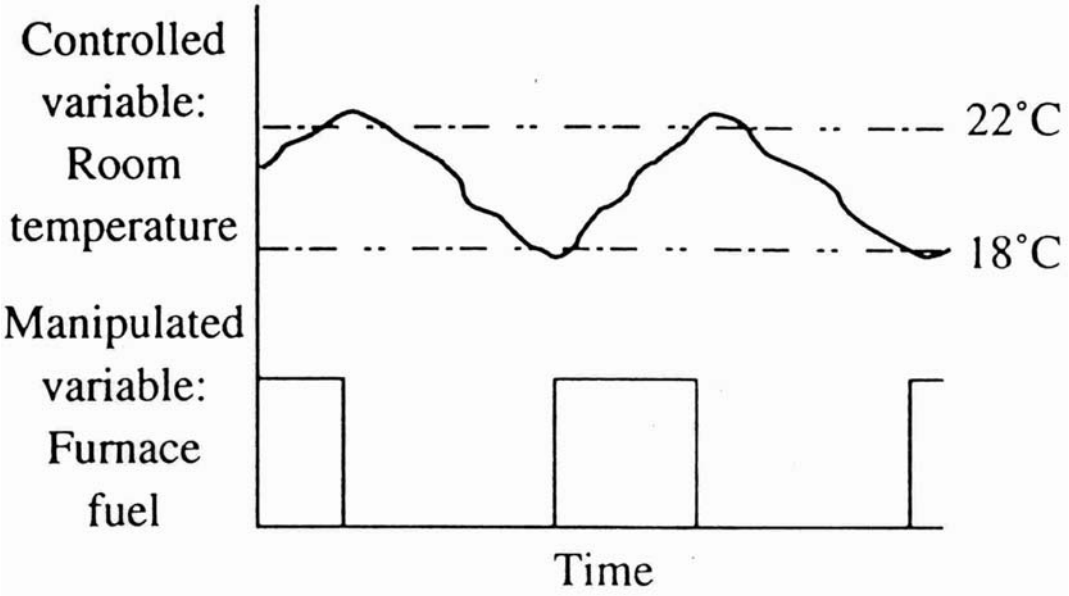
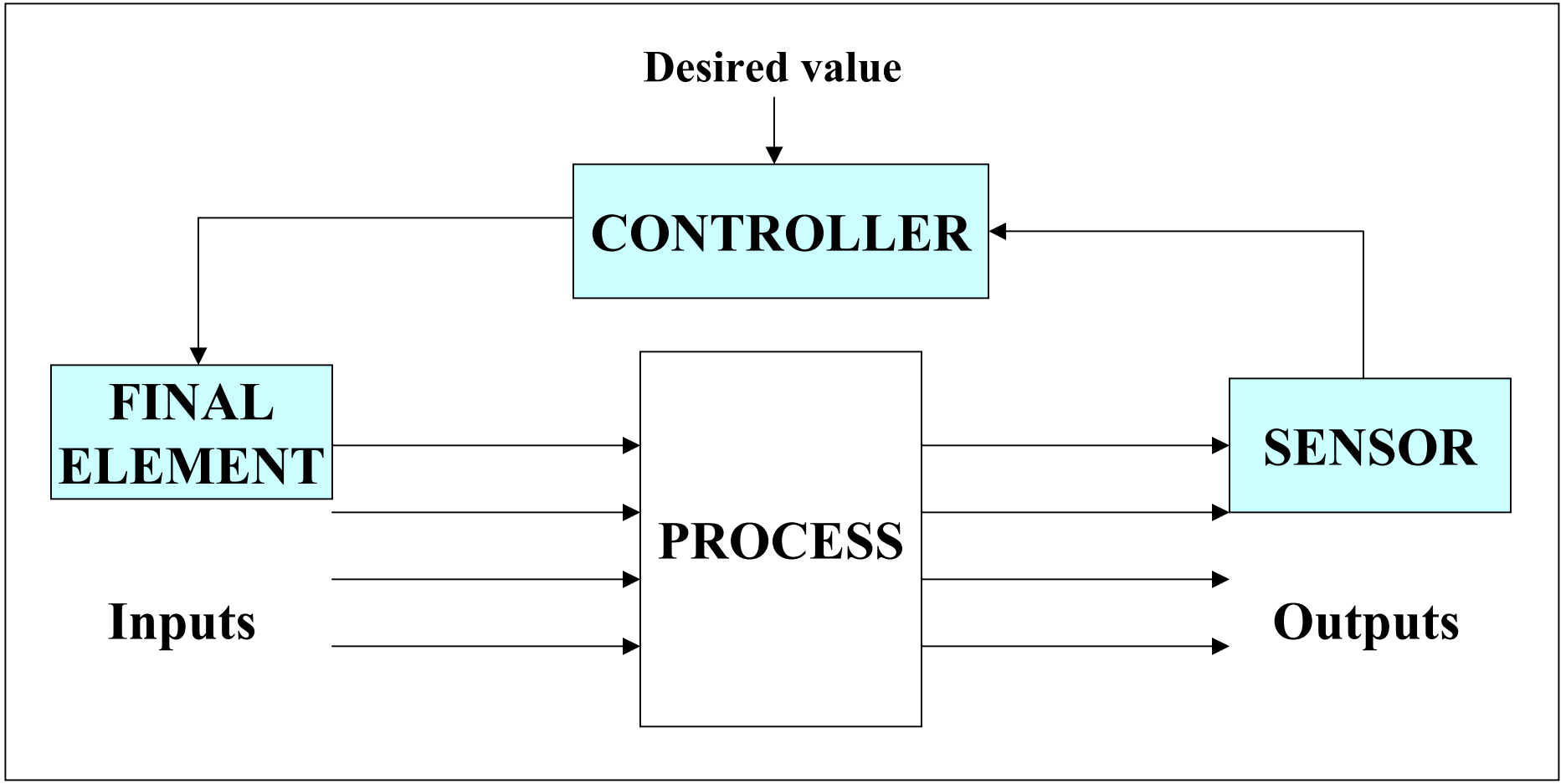


FIGURE 1.3

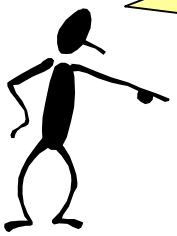
Is this good enough for all variables in a chemical process? Hint: if "yes", the course is over!

WHAT DOES A FEEDBACK SYSTEM DO?

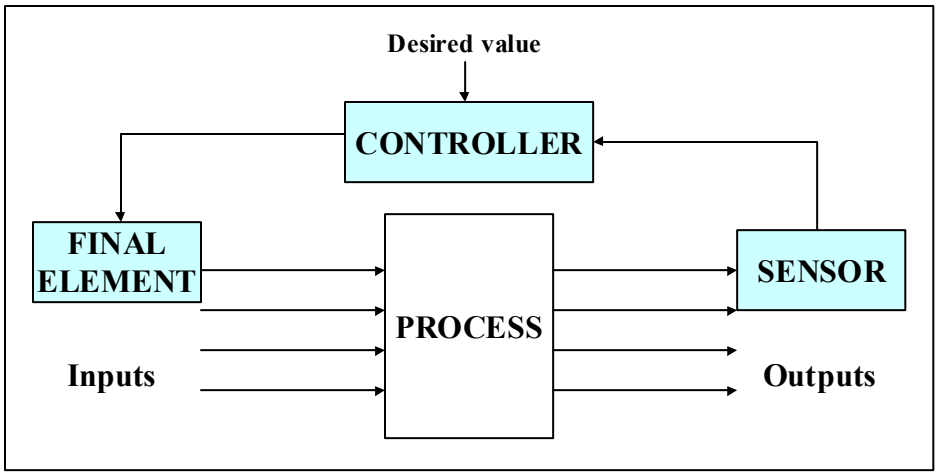
The control systems appear to have three basic elements.



WHAT DOES A FEEDBACK SYSTEM DO?



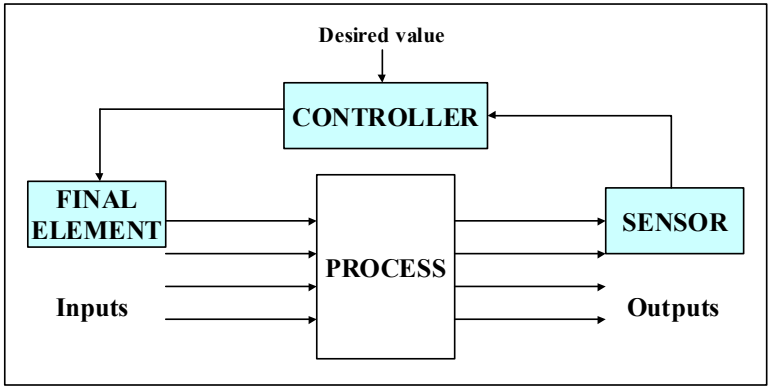
What is a typical “final element” for chemical processes?



What is the meaning of the arrows?

How do we select the sensor location?

WHAT DOES A FEEDBACK SYSTEM DO?



CONTROL (verb): To maintain desired conditions in a physical system by adjusting selected variables in the system.

FEEDBACK CONTROL makes use of an output of a system to influence an input to the same system.

input = cause ⟶ output = effect

WHAT DOES A FEEDBACK SYSTEM DO?

Caution: Common misunderstanding in terminology!

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Positive feedback: That was a good idea. Thank you!

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Engineering & Science

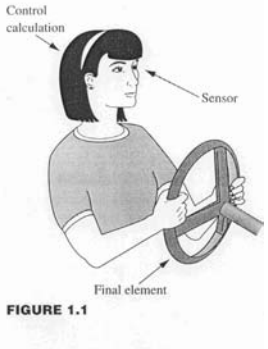

FIGURE 1.1

Negative feedback: Action to reduce the error from desired.

Positive feedback: Action to increase the error from desired.

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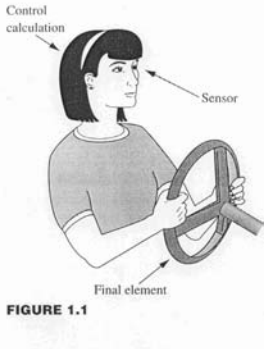


FIGURE 1.1

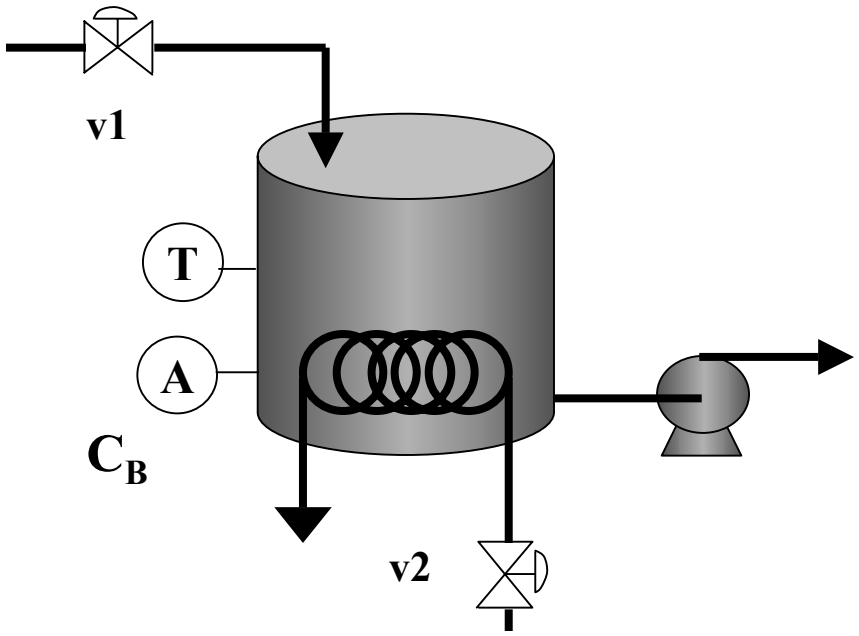
Negative feedback: Action to reduce the error from desired.

Good!

Positive feedback: Action to increase the error from desired.

WHY IS CONTROL NECESSARY?

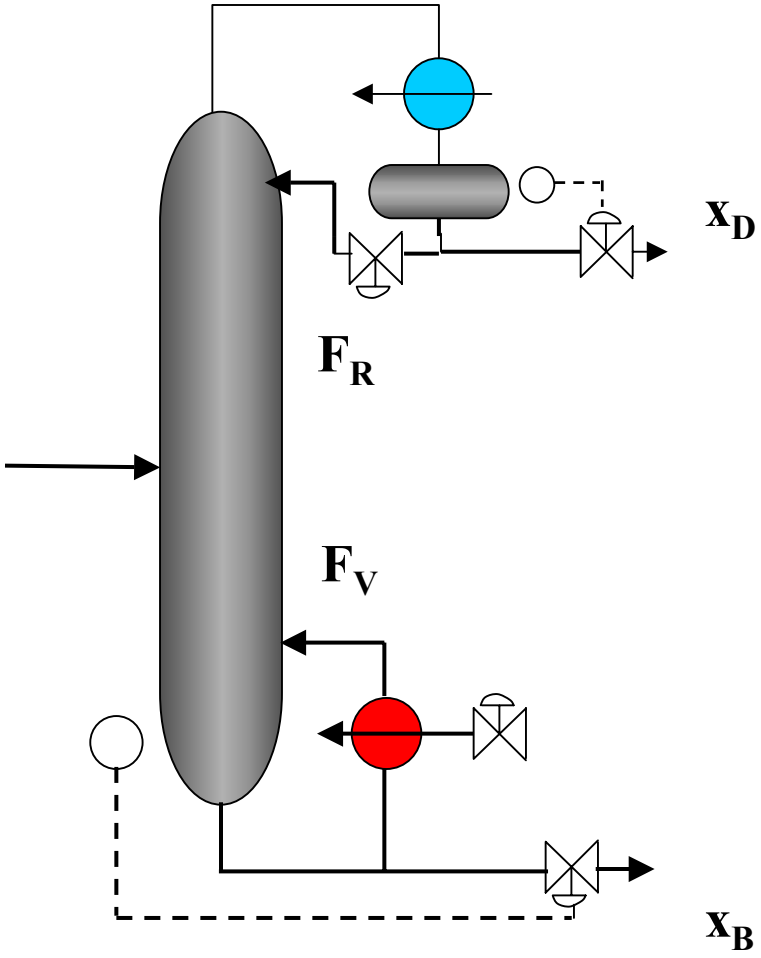
One word: DISTURBANCES! Give some examples in the CSTR in the figure.



We want to achieve the following:

1. **Safety**
2. **Environmental Protect.**
3. **Equipment protect.**
4. **Smooth operation**
5. **Product quality**
6. **Profit**
7. **Monitoring and diagnosis**

WHY IS CONTROL NECESSARY?



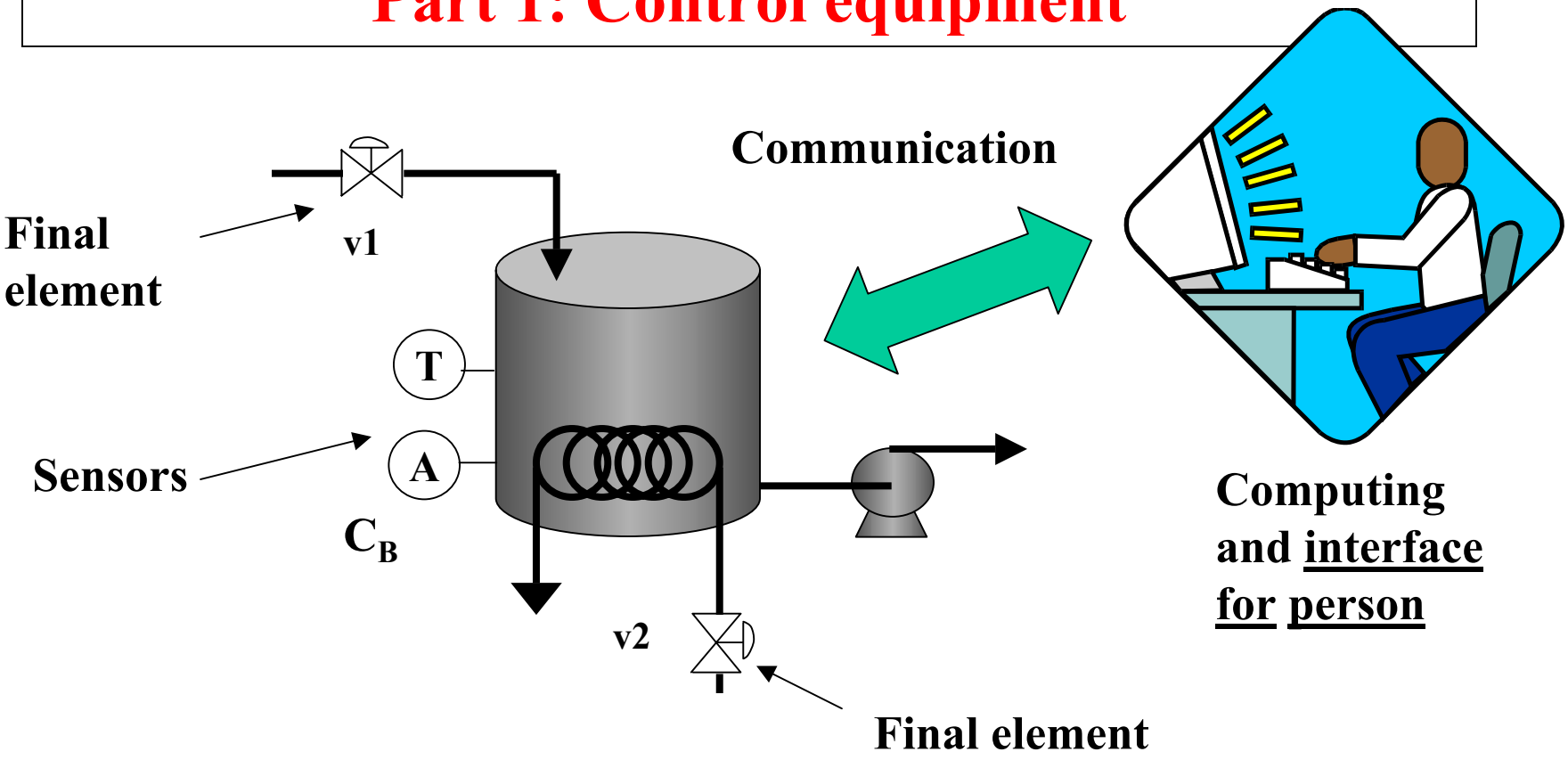
One word:
DISTURBANCES!

Give some examples in the distillation tower in the figure.

WHY IS CONTROL POSSIBLE?

Control is possible only if the engineer provides the required equipment during process design.

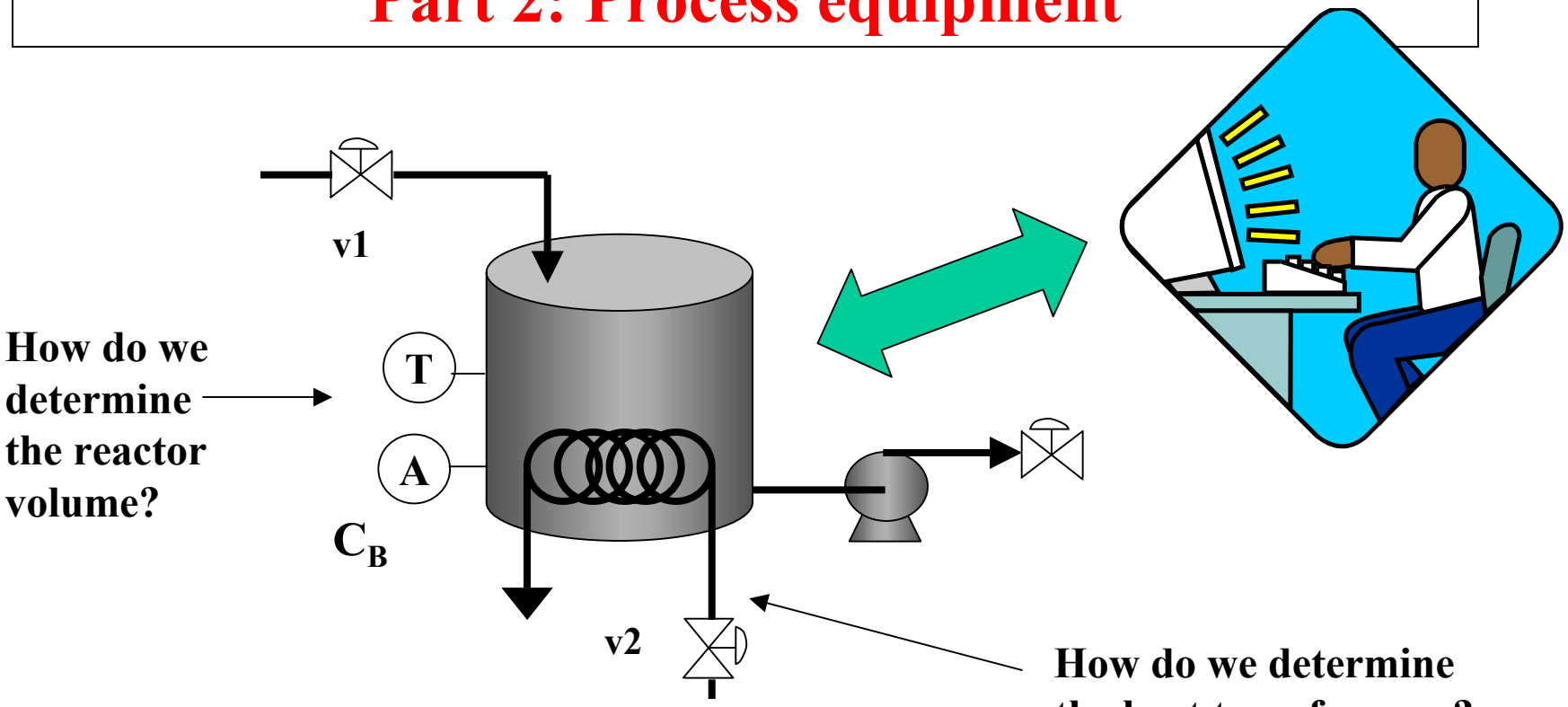
Part 1: Control equipment



WHY IS CONTROL POSSIBLE?

Control is possible only if the engineer provides the required equipment during process design.

Part 2: Process equipment



WHERE IS CONTROL DONE?

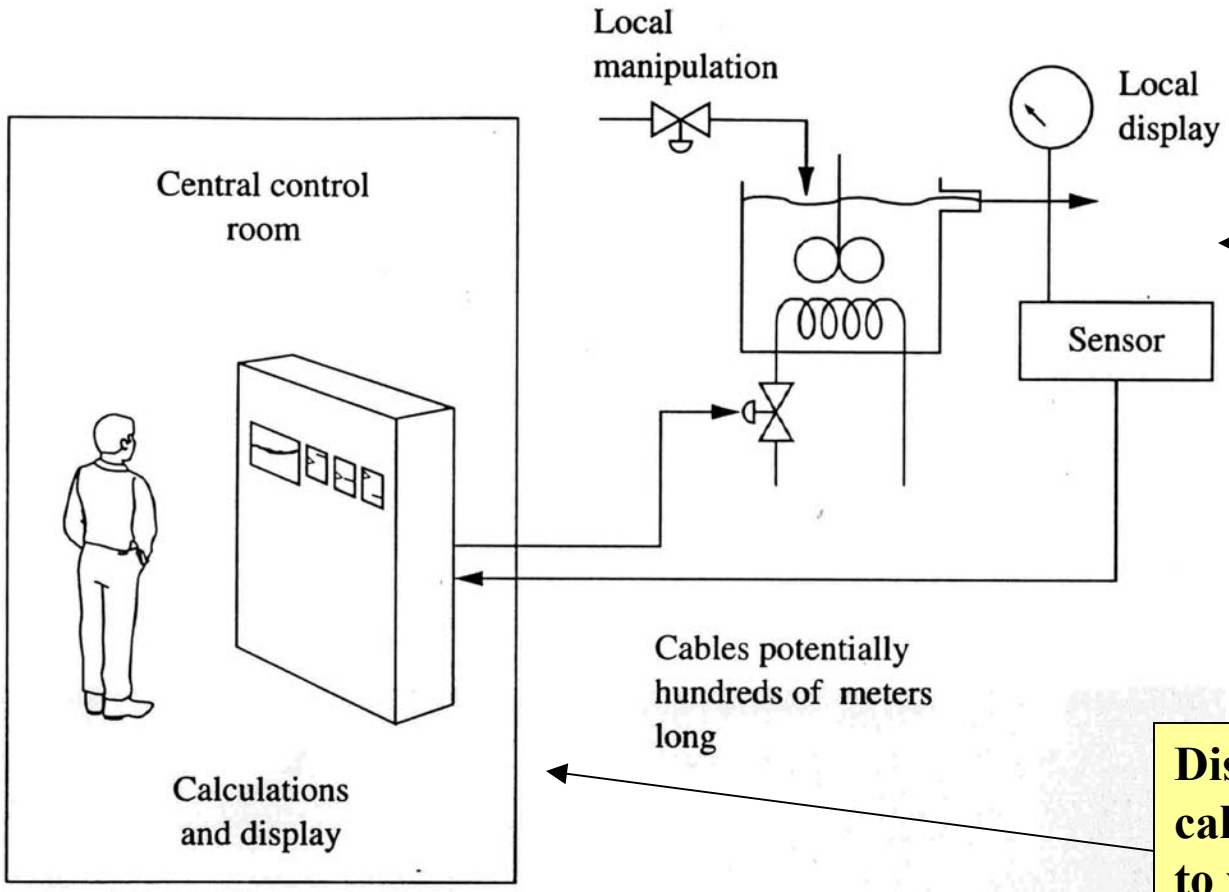


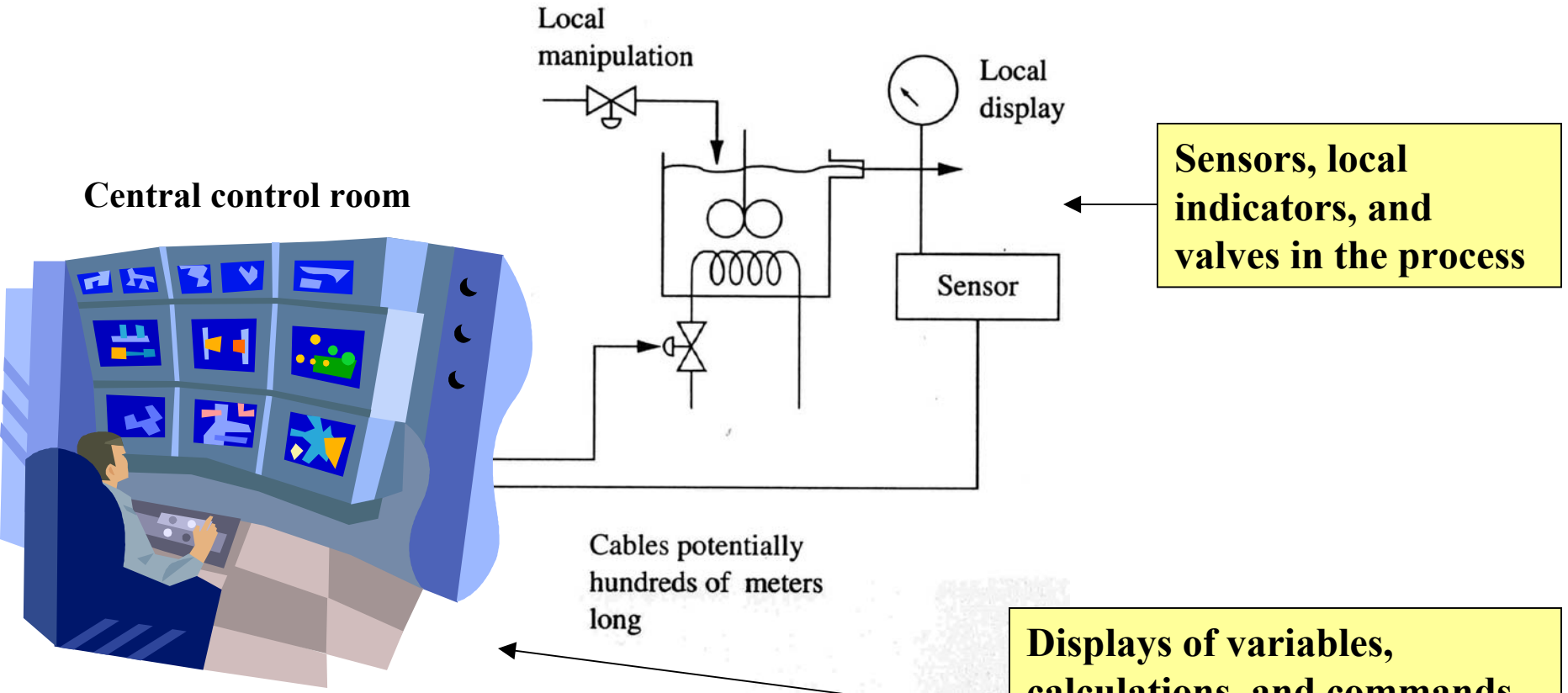
FIGURE 1.6

Shows an older-style control panel

Sensors, local indicators, and valves in the process

Displays of variables, calculations, and commands to valves are in the centralized control center.

WHERE IS CONTROL DONE?



Sensors, local indicators, and valves in the process

Displays of variables, calculations, and commands to valves are in the centralized control center.

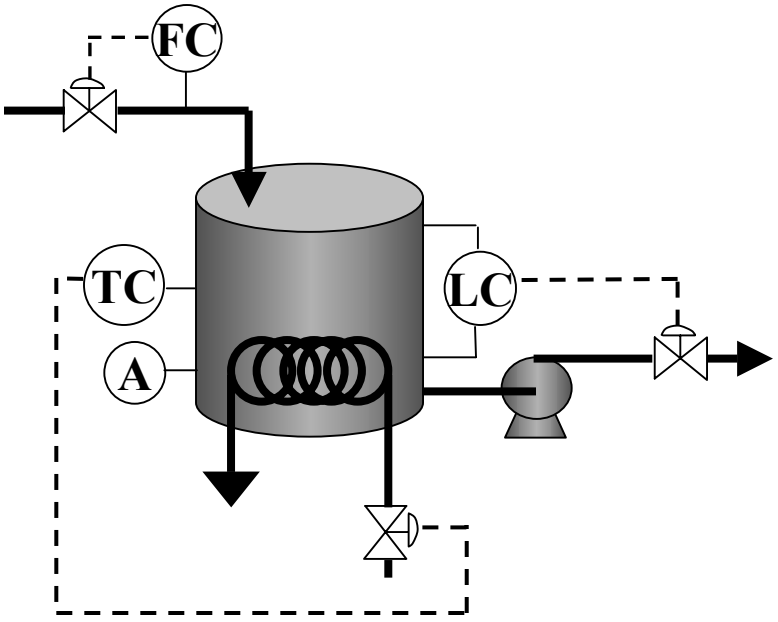
FIGURE 1.6

Shows a modern, computer-based control panel

HOW IS CONTROL DESIGN DOCUMENTED?

Piping and instrumentation (P&I) drawings provide documentation.

- **The system is too complex to describe in text.**
- **We must use standard symbols.**



F = flow

L = level

P = pressure

T = temperature

…..

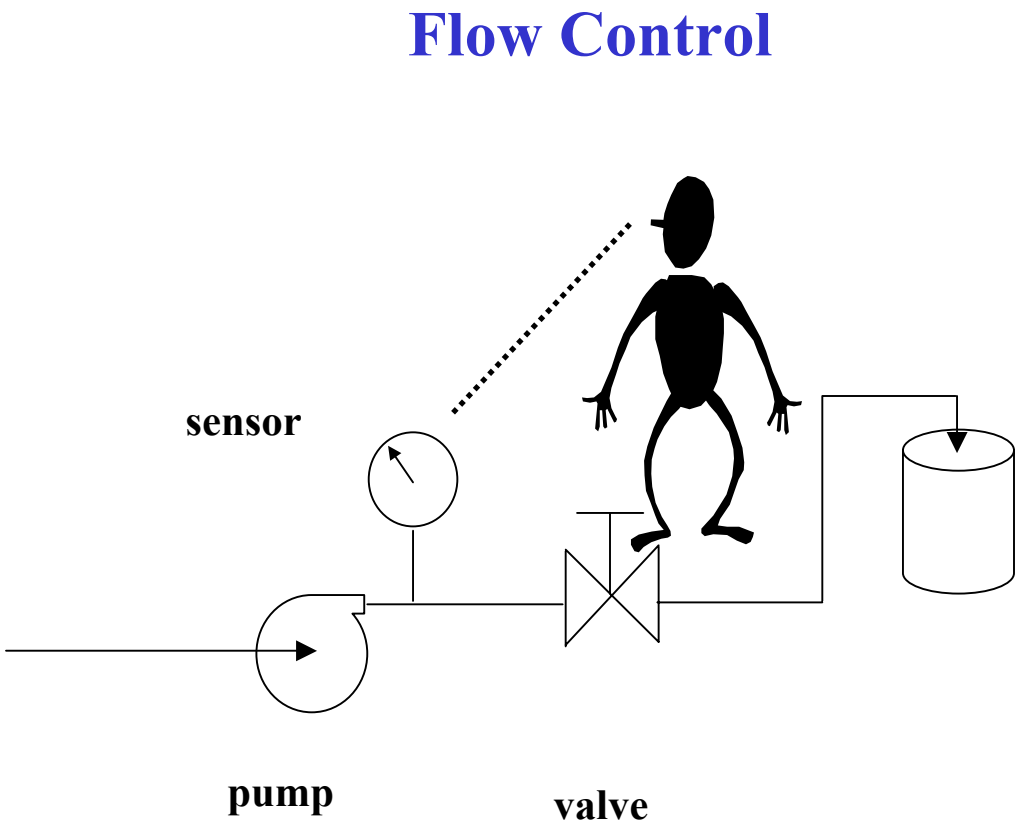
CHAPTER 1: INTRODUCTION - WORKSHOP 1

You are implementing control “manually”.

a. Explain the principle for a typical flow sensor

b. Explain how the final element affects the controlled variable.

c. Explain the correct action if you want to increase the controlled variable



CHAPTER 1: INTRODUCTION - WORKSHOP 2

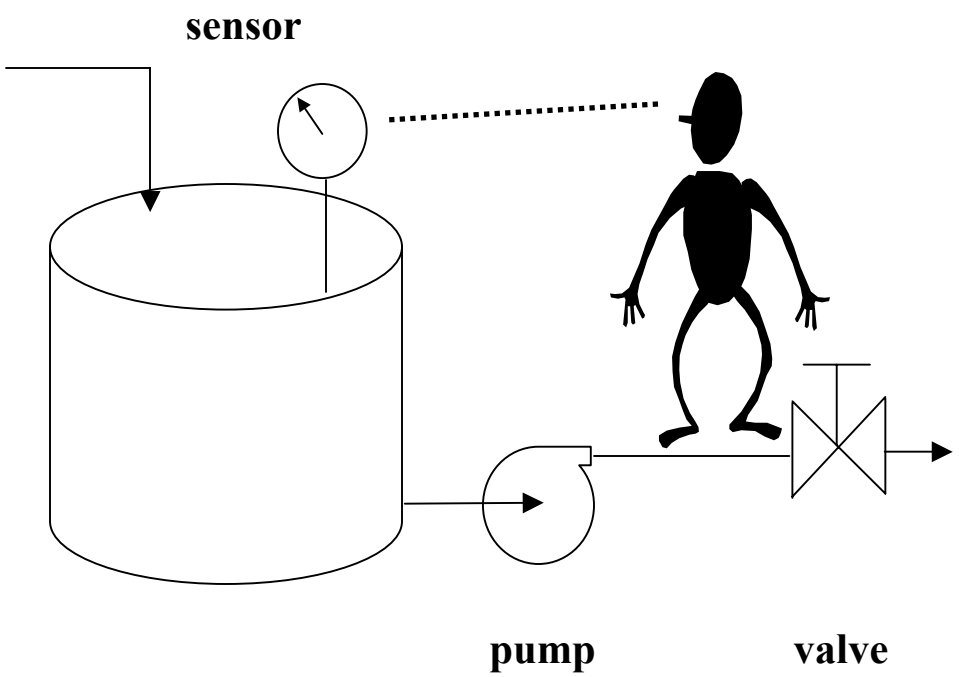
You are implementing control "manually".

a. Explain the principle for a typical liquid level sensor

b. Explain how the final element affects the controlled variable.

c. Explain the correct action if you want to increase the controlled variable

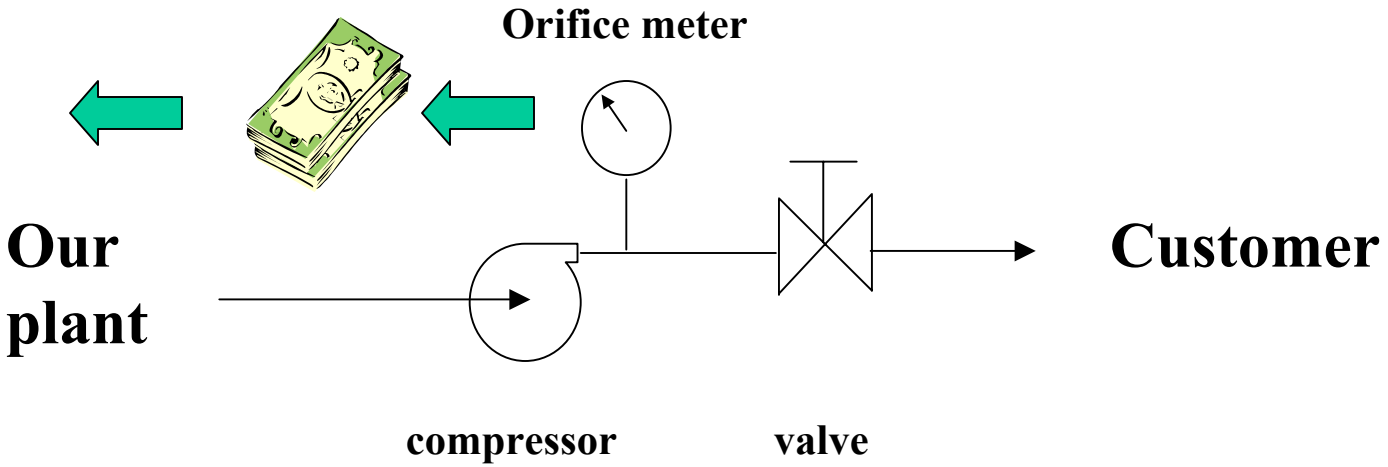
Level Control



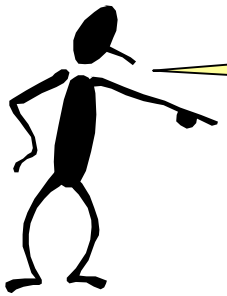
CHAPTER 1: INTRODUCTION - WORKSHOP 3

You are selling a gas to a customer based on the volumetric flow at standard conditions. You decide to use an orifice meter to measure the flow rate.

You have learned that the gas flow density may change by -10% from its design (expected) value. What do you do?



CHAPTER 1 : INTRO. TO PROCESS CONTROL



How are we doing?

- **Explain the feedback concept applied to control**
- **Explain and identify the three elements in a feedback loop**
- **Be able to apply feedback manually to many chemical process examples**

Lot's of improvement, but we need some more study!

- **Read the textbook**
- **Review the notes, especially learning goals and workshop**
- **Try out the self-study suggestions**
- **Naturally, we'll have an assignment!**

CHAPTER 1: LEARNING RESOURCES

- **SITE PC-EDUCATION WEB**

  - Instrumentation Notes

  - Interactive Learning Module (Chapter 1)

  - Tutorials (Chapter 1/2)

- **Textbook Appendix A on drawing symbols**

  - See references for much more detail or symbols

CHAPTER 1:
SUGGESTIONS FOR SELF-STUDY

1. **Write down the rules (algorithm) that you use when you drive an automobile or bicycle.**
2. **Formulate questions with answers and trade with members of your study group.**
3. **Find a P&I drawing in one of the textbook references (or recent volume of *Chemical Engineering Progress*), explain the strategy, and prepare questions for your instructor on aspects that you do not understand.**
4. **Find examples of control systems in your house. (Hint: look at the heating, air conditioning, toilet tank, and the most highly automated room, the kitchen.**