IPE 301

Instrumentation and Control

Chapter 4

Control Systems

Introduction

Automation:

- **The term automation is used to describe the automatic operation or control of a process.**
- **Automation involves carrying out operations in the required sequence and controlling outputs to required values.**
- **Example: Automatically operating machinery (in a production line with robots) can be used to produce components with virtually no human intervention.**

Introduction

Benefits of Automation: **The benefits of automatic control of machines and processes include**

- ✓ **greater consistency of product**
- ✓ **reduced operating costs due to improved utilization of plant and materials**
- ✓ **a reduction in manpower**
- ✓ **greater safety for operating personnel**

What Control System Can Do

Control a variable to obtain the required value:

- **Setting the required temperature in an air-conditioning system**
- **In a bottling plant the bottles are automatically filled to the required level.**
- **A computer-numerical-control (CNC) machine tool is used to automatically machine a workpiece to the required shape.**
- **Packets of biscuits moving along a conveyor belt have their weights checked and those that are below the required minimum weight limit are automatically rejected.**

What Control System Can Do

Control the sequence of events:

- **A belt is used to feed blanks to a pressing machine. As a blank reaches the machine, the belt is stopped, the blank positioned in the machine, the press activated to press the required shape, then the pressed item is ejected from the machine and the entire process repeated.**
- **You set the dials on the automatic clothes washing machine to indicate that 'whites' are being washed and the machine then goes through the complete washing cycle appropriate to that type of clothing.**

What Control System Can Do

Control whether an event occurs or not:

- **The automatic clothes washing machine has a safety lock on the door so that the machine will not operate if the power is off and the door open.**
- ***CNC* machines also incorporate safety lock on the door.**

Control Systems

A control system can be thought of as a system which for some particular input or inputs is used to control its output to some particular value, give a particular sequence of events or give an event if certain conditions are met.

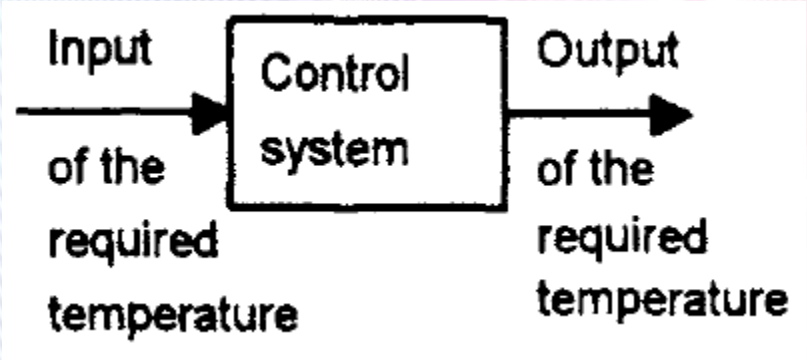


Fig: Central Heating System

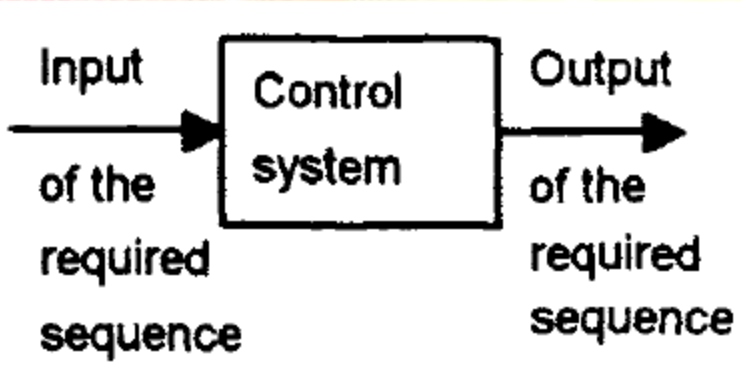


Fig: Clothes Washing Machine System

Open-loop and Closed-loop Control

Consider two alternative ways of heating a room to some required temperature.

❖ **Selection switch allows a 1 kW or a 2 kW heating element to be selected**

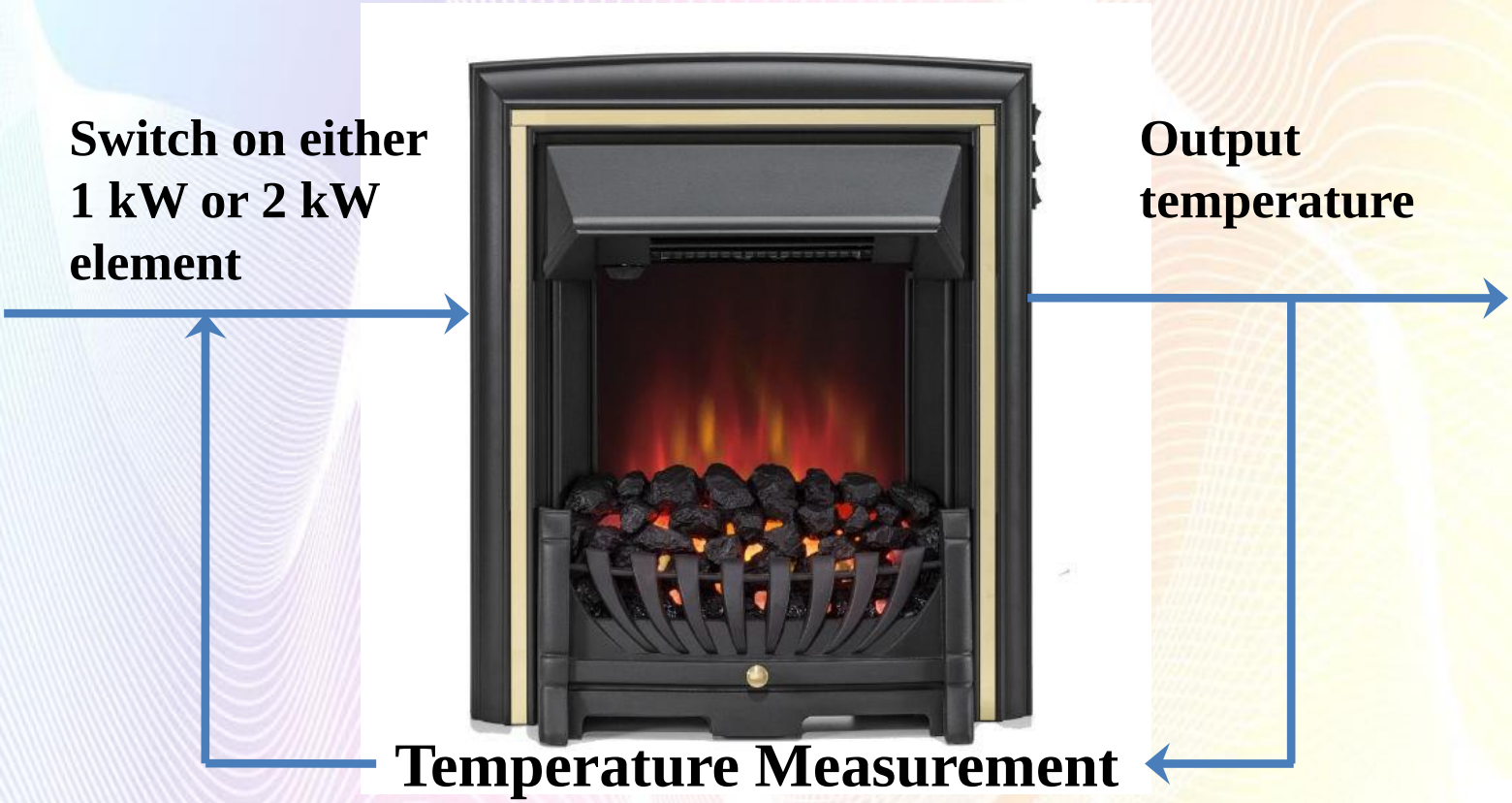
Switch on either 1 kW or 2 kW element

Output temperature

❖ **The temperature of the room is thus controlled by an initial decision and no further adjustments are made.**

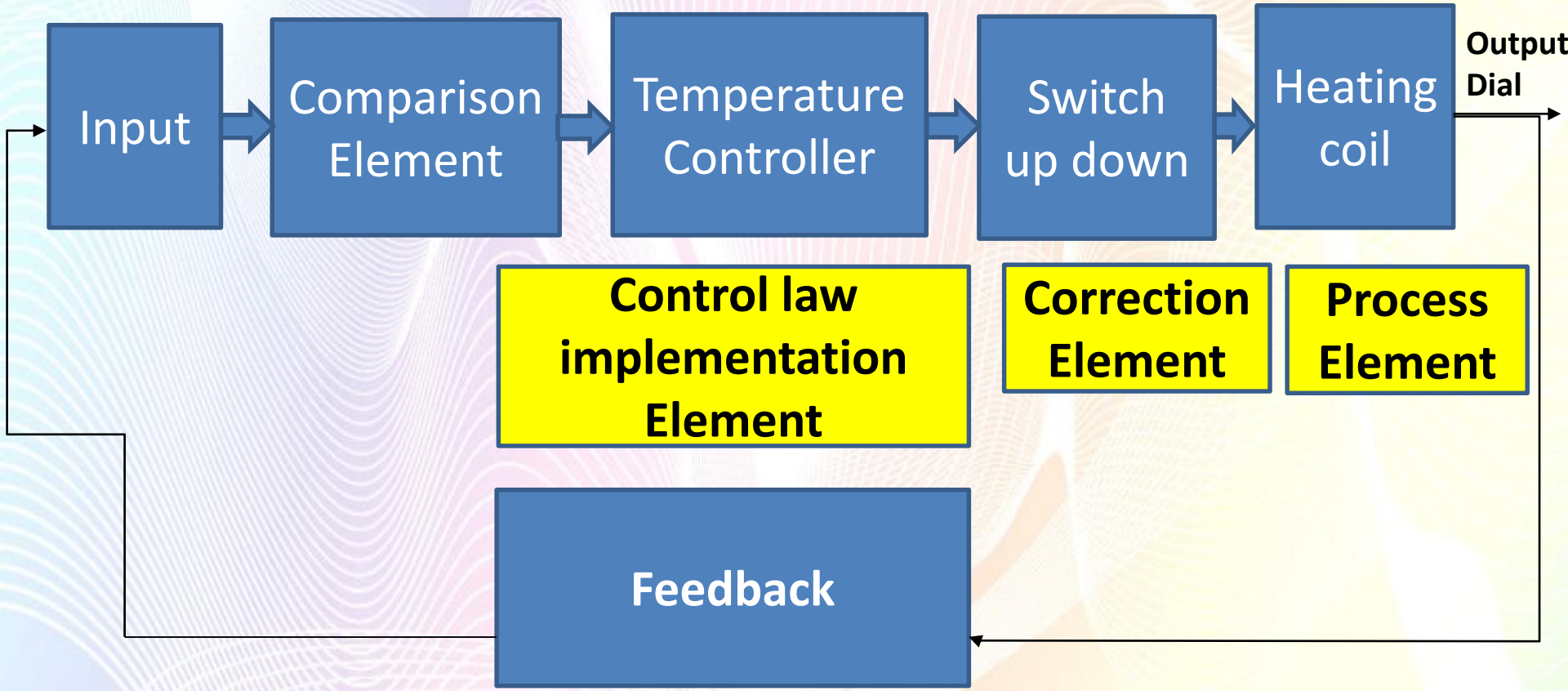
❖ **No information about the output is fed back.**

Open-loop and Closed-loop Control

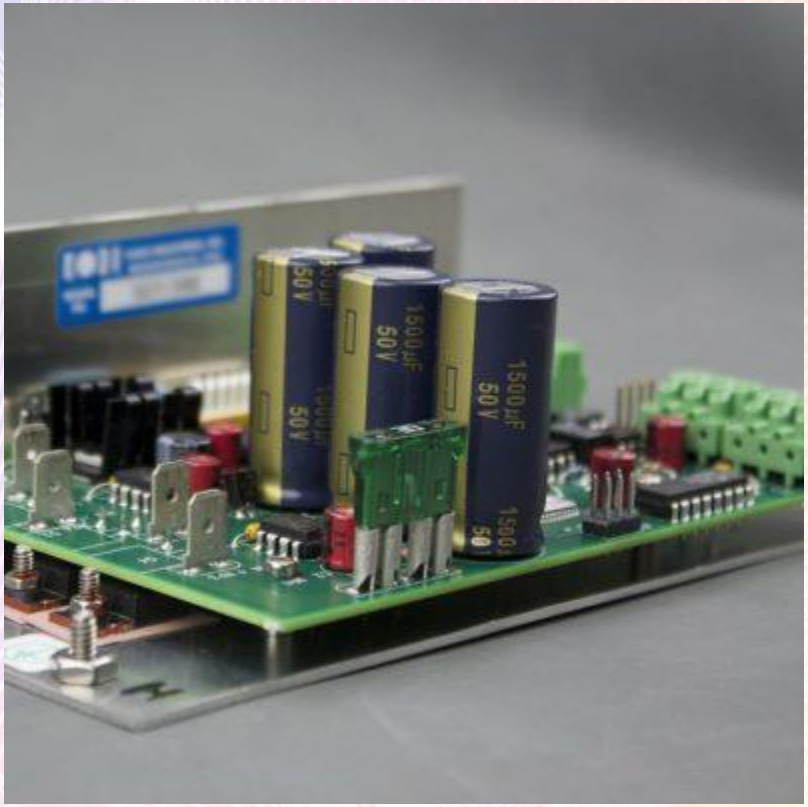


❖ There is feedback, information being fed back from the output to modify the input to the system.

Closed Loop System of a Heater



Temperature Controller



Motor Controller

Closed-loop Control

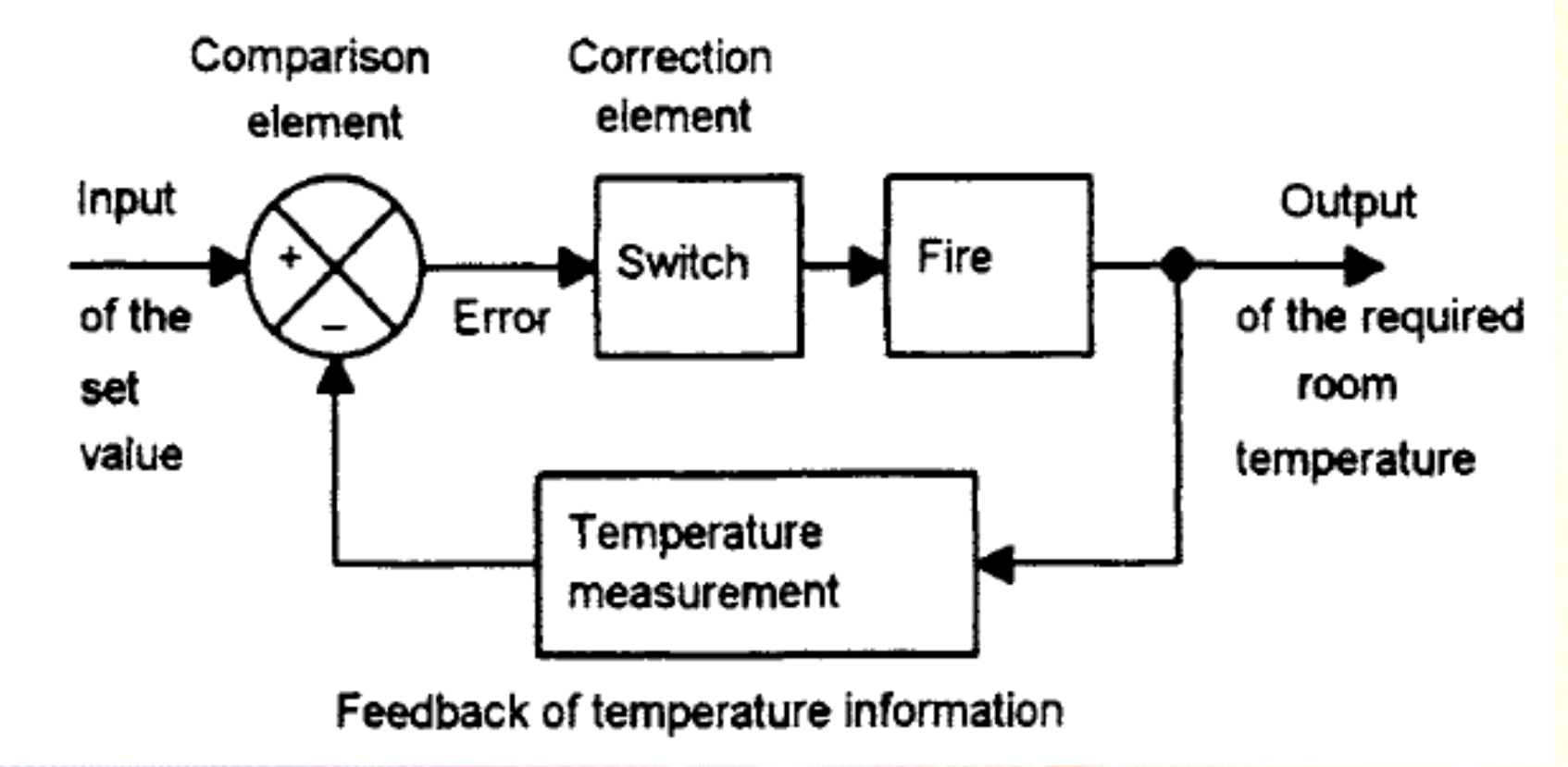


Fig: The electric fire closed-loop system

- **+ set value - feedback value = error**
- **Because the feedback signal is subtracted from the set value signal, the system is said to have negative feedback.**

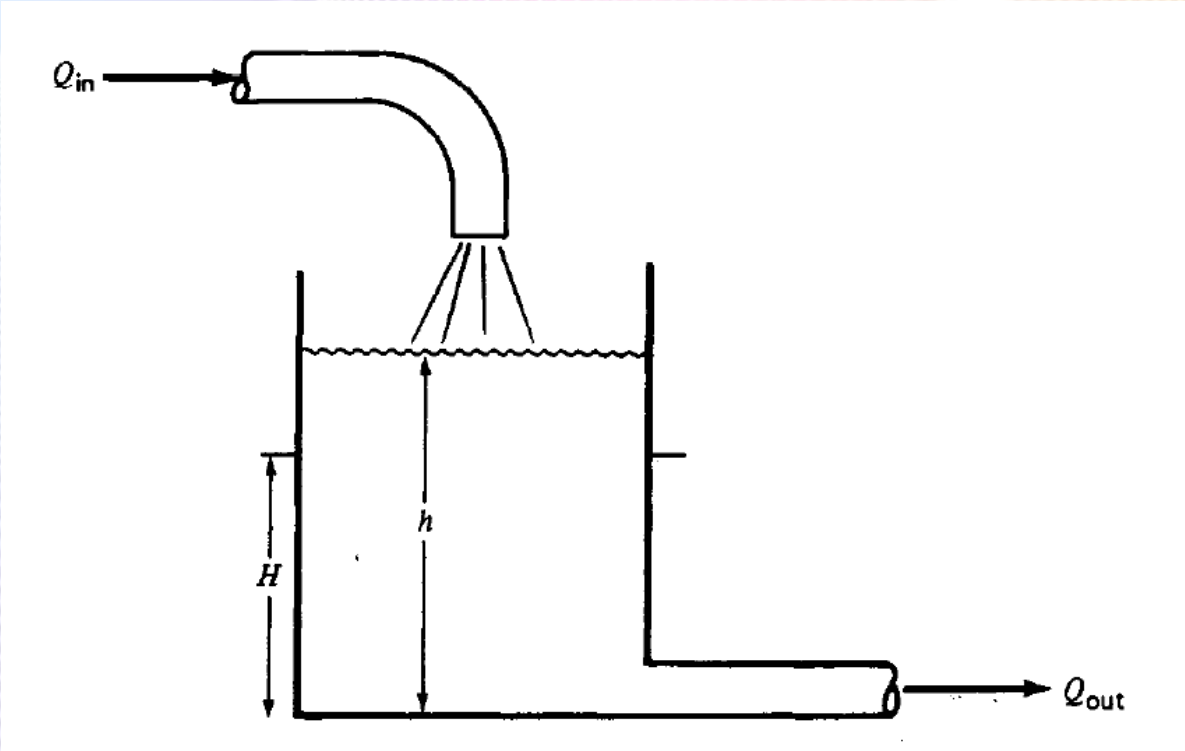
Paths of Signals

- Feedback path
  1) Positive Feedback Path
  2) Negative Feedback Path
- Forward path

Process Control

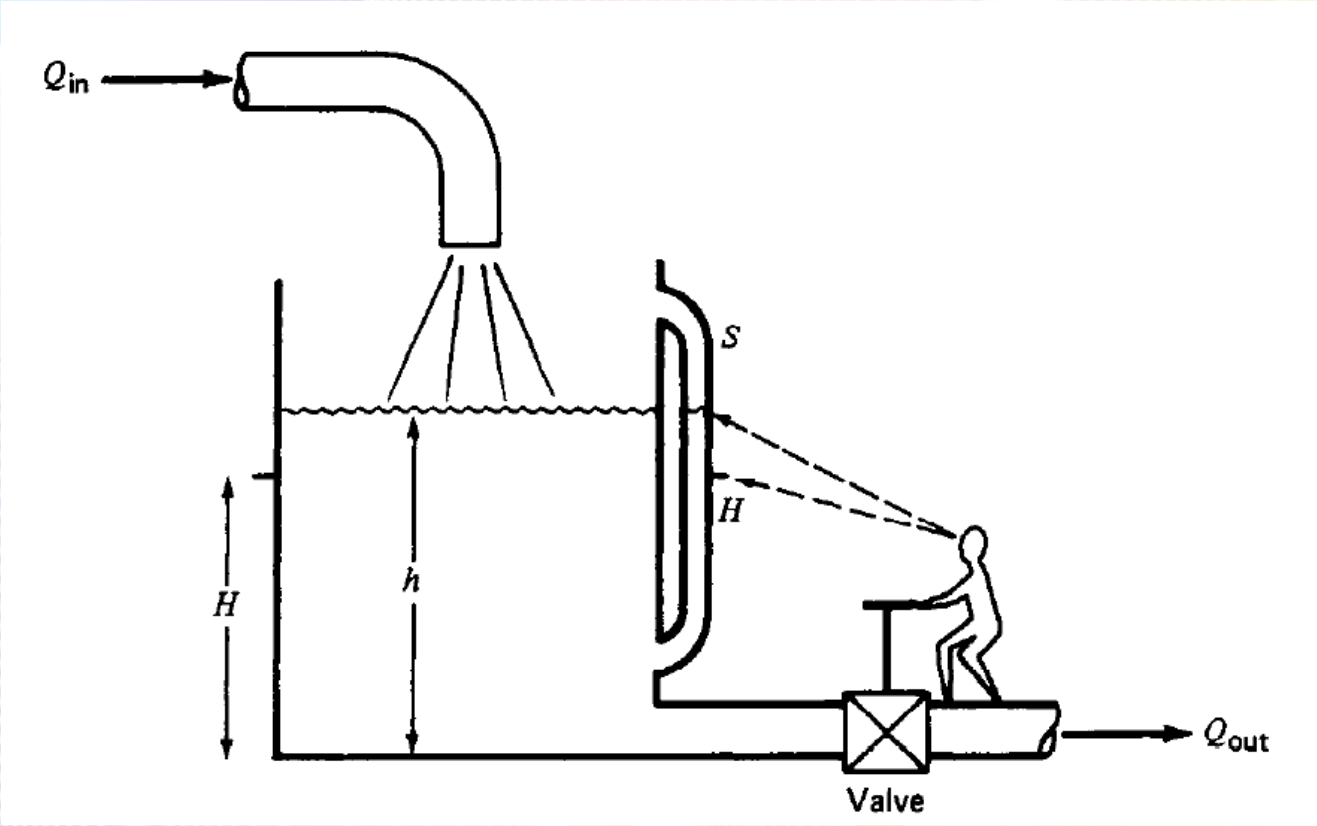
When automatic control is applied to systems (like the one shown in the previous slide) which are designed to regulate the value of some variable to a setpoint, it is called *Process Control*.

Process Control



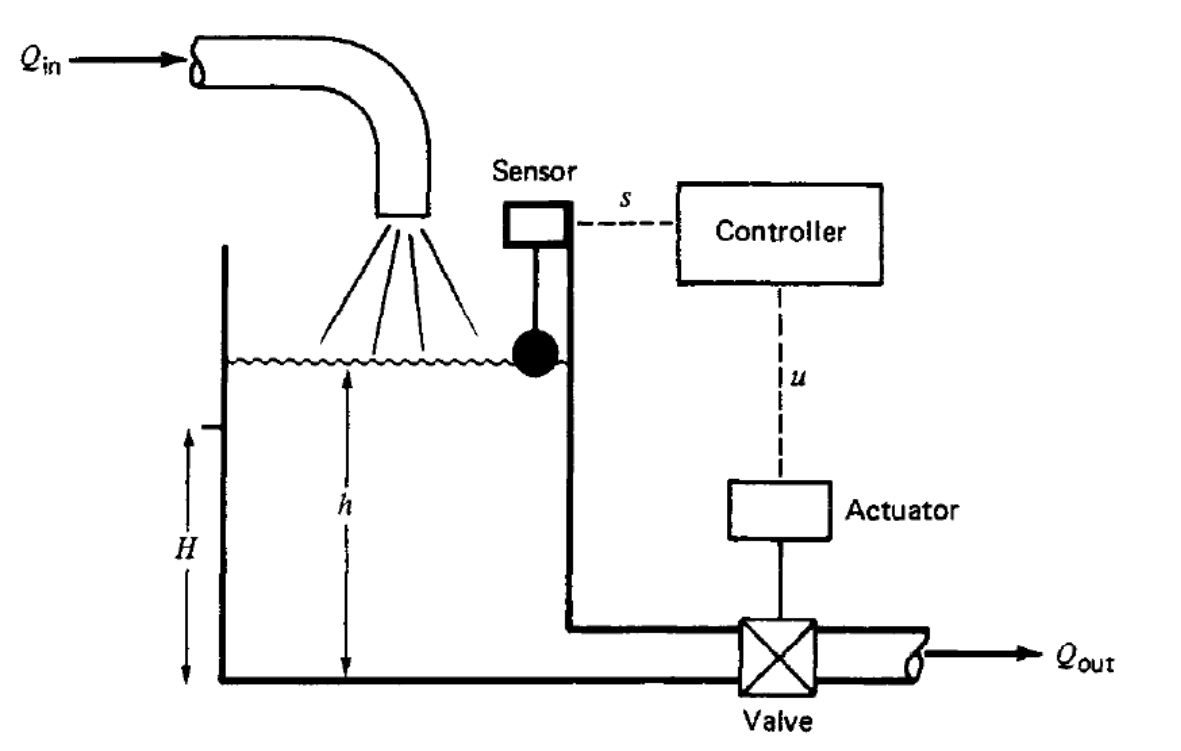
- **The objective is to regulate the level of liquid in the tank, *h*, to the value *H***

Process Control



- **A human can regulate the level using a sight tube, *S*, to compare the level *h*, to the objective, *H*, and adjust a valve to change the level.**

Process Control

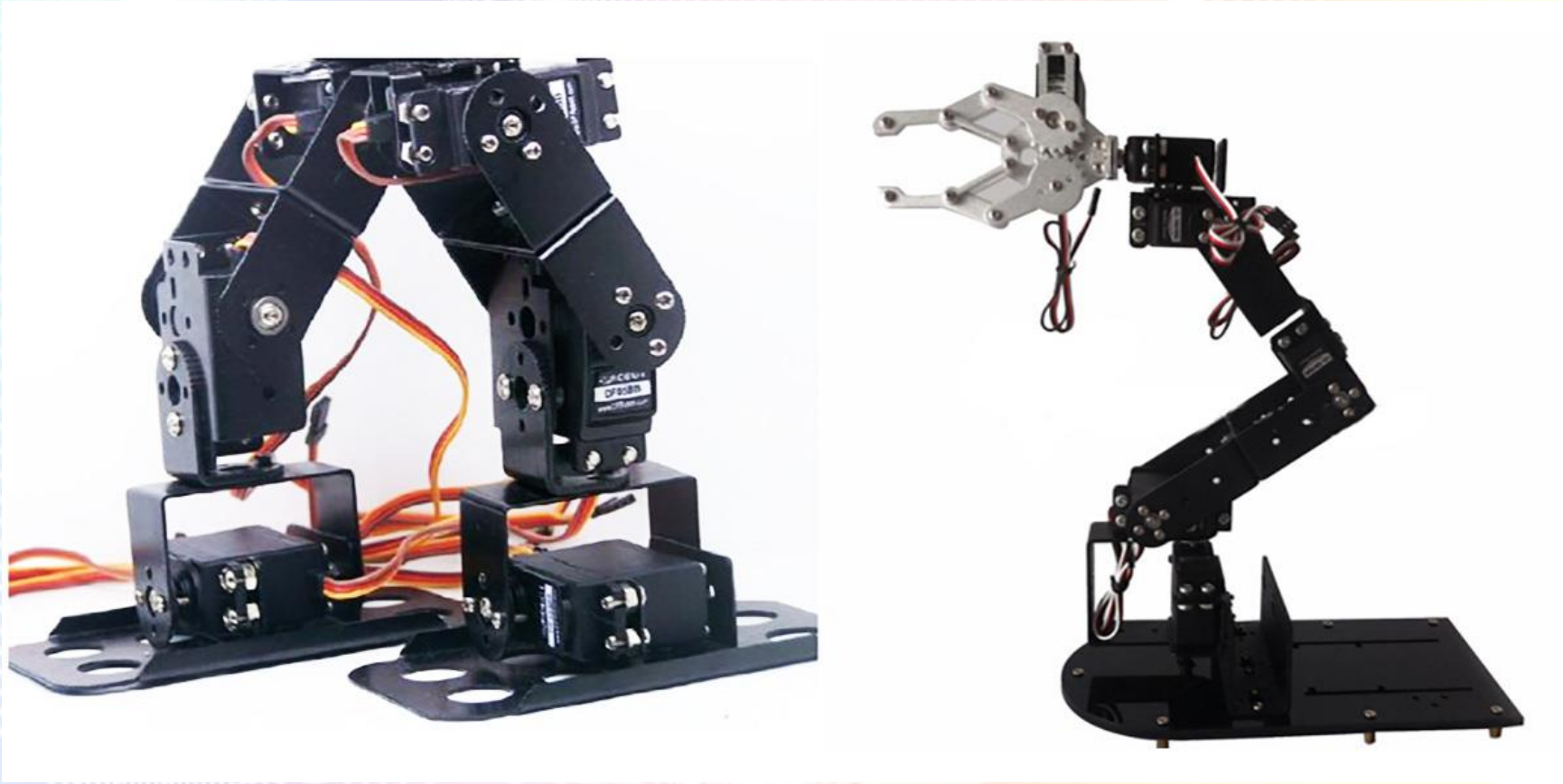


- **An automatic level-control system replaces the human by a controller and uses a sensor to measure the level.**

Servomechanism (continuous process)

- **This is another type of control system in common use.**
- **It has slightly different objective from *process control*.**
- **The objective is to force some parameter to vary in a specific manner.**
- **Instead of regulating a variable value to a setpoint, the servomechanism forces the controlled variable to follow variation of the reference value.**

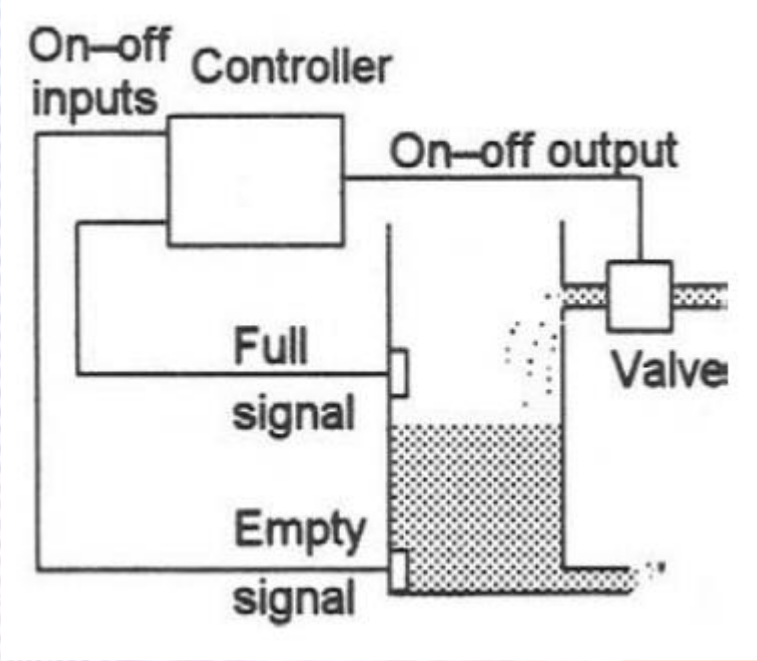
Servomechanism



Robot Motors

Discrete-Time Control Systems

- **Discrete-time control systems are control systems in which one or more inputs can change only at discrete instants of time.**
- **The inputs are effectively on-off signals and so in digital form.**
- **This form of control is often called sequential control.**
- **It describes control systems involving logic control functions.**



❖ **The controller switches the valve open when empty signal received and closed when the full signal**

Discrete-Time Control Systems

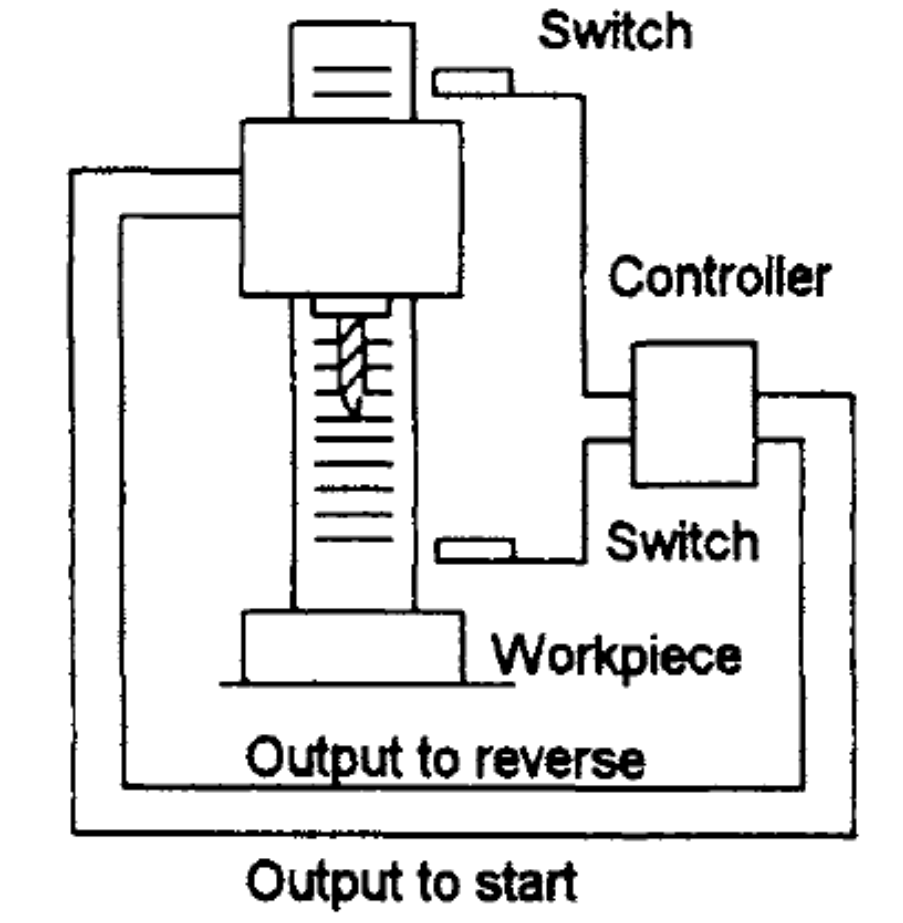


Fig: An automatic drill