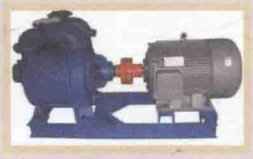
Section A

Pre-reading

1 Identify the following words and match the words with the pictures listed below.

water clock　furnace　water-ring vacuum pump
compressor　thermostat　pressure regulator



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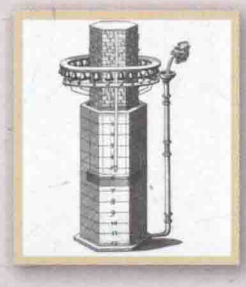

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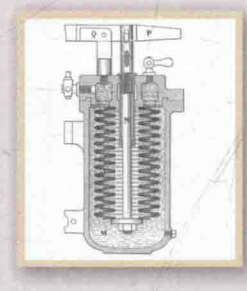


6. _____

2 Discuss the following questions with your partner.

1. What do you know about automatic control? When did automatic control first appear in human history?
2. Which field is automatic control the most widely applied in? How can it be well incorporated into other fields?

Text A

Automatic Control

1 Automatic control in engineering and technology is a wide generic term covering the application of mechanisms to the operation and regulation of processes without continuous direct human intervention.

2 Automatic control covers the range of application from a household thermostat controlling a boiler, to a large industrial control system with tens of thousands of input measurements and output control signals. In control complexity it can range from simple on-off control to multi-variable high level algorithms.

3 In the simplest type of an automatic control loop, a controller compares a measured value of a process with a desired set value, and processes the resulting error signal to change some input to the process, in such a way that the process stays at its set point despite disturbances. This closed-loop control is an application of negative feedback to a system. The mathematical basis of control theory was begun in the 18th century, and advanced rapidly in the 20th century.

4 The history of automatic control traces back to Ancient Greece. It was a preoccupation of the Greeks and Arabs (in the period between about 300 B.C. and about 1200 A.D.) to keep accurate track of time. In about 270 B.C. the Greek Ctesibius invented a float for a water clock, a device not unlike the ball and cock in a modern flush toilet. The invention of the mechanical clock in the 14th century made the water clock and its feedback control system obsolete. The float regulator does not appear again until its use in the Industrial Revolution.

5 Thomas Newcomen invented the steam engine in 1713, and this date marks the accepted beginning of the Industrial Revolution. However, its roots can be traced back into the 17th century. The introduction of prime movers, or self-driven machines advanced grain mills, furnaces, boilers, and the steam engine created a new requirement for automatic control systems including temperature regulators (invented in 1624), pressure regulators (1681), float regulators (1700) and speed control devices. The design of

feedback control systems up through the Industrial Revolution was done by trial-and-error, together with a great deal of engineering intuition. Thus, it was more of an art than a science. In the mid-19th century mathematics was first used to analyze the stability of feedback control systems. Since mathematics is the formal language of automatic control theory, we could call the period before this time the prehistory of control theory.

6 The First and Second World Wars saw major advancements in the field of mass communication and signal processing. Other key advances in automatic control include differential equations, stability theory and system theory, frequency domain analysis, ship control, and stochastic analysis.

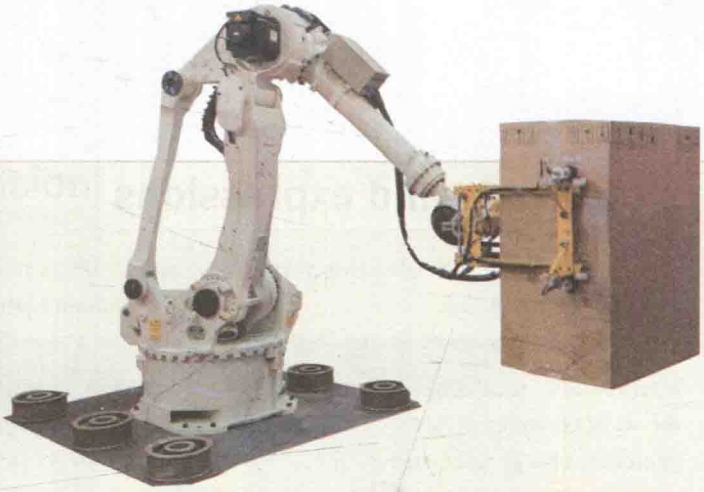
7 With the advent of the space age in 1957, controls design, particularly in the United States, turned away from the frequency-domain techniques of classical control theory and backed into the differential equation techniques of the late 19th century, which were couched in the time domain. The modern era saw time-domain design for nonlinear systems, navigation, optimal control and estimation theory, nonlinear control theory, digital control and filtering theory, and the personal computer.

8 Fundamentally, there are two types of control loop: open loop control and closed loop control.

9 In open loop control, the control action from the controller is independent of the process output. A good example of this is a central heating boiler controlled only by a timer, so that heat is applied for a constant time, regardless of the temperature of the building.

10 In closed loop control, the control action from the controller is dependent on the process output. In the case of the boiler analogy this would include a thermostat to monitor the building temperature, and thereby feed back a signal to ensure the controller maintains the building at the temperature set on the thermostat. A closed loop controller therefore has a feedback loop which ensures the controller exerts a control action to give a process output the same as the "reference input" or "set point". For this reason, closed loop controllers are also called feedback controllers.

11 The definition of a closed loop control system according to the British Standard Institution is "a control system possessing monitoring feedback, the deviation signal formed as a result of this feedback being



used to control the action of a final control element in such a way as to tend to reduce the deviation to zero".

12 Likewise, a feedback control system is a system which tends to maintain a prescribed relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control.

13 The advanced type of automation that revolutionized manufacturing, aircraft, communications and other industries, is feedback control, which is usually continuous and involves taking measurements using a sensor and making calculated adjustments to keep the measured variable within a set range. The theoretical basis of closed loop automation is control theory.

14 A thermostat is a simple negative feedback controller: when the temperature (the "process variable" or PV) goes below a set point (SP), the heater is switched on. Another example could be a pressure switch on an air compressor. When the pressure (PV) drops below the threshold (SP), the pump is powered. Refrigerators and vacuum pumps contain similar mechanisms operating in reverse, but still providing negative feedback to correct errors.

15 Simple on-off feedback control systems like these are cheap and effective. In some cases, like the simple compressor example, they may represent a good design choice.

16 In most applications of on-off feedback control, some consideration needs to be given to other costs, such as wear and tear of control valves and perhaps other start-up costs when power is reapplied each time the PV drops. Therefore, practical on-off control systems are designed to include hysteresis which acts as a deadband, a region around the set point value in which no control action occurs. The width of deadband may be adjustable or programmable.

New words and expressions

generic /dʒɪ'nerɪk/ *adj.*
relating to all members of a genus 类的；属的

intervention /ˌɪntə'venʃən/ *n.*
the act of becoming involved in a certain situation in order to change what happens 介入；干预

variable /'veərɪəbl/ *n.*
sth. that is likely to vary 变量；可变因素

algorithm /'ælgərɪðəm/ *n.* 运算法则

feedback /'fiːdbæk/ *n.*
the process in which part of the output of a system is returned to its input in order to regulate its further output 反馈

preoccupation /priːɒkjʊ'peɪʃən/ *n.*
the mental state of being preoccupied by sth. 全神贯注

obsolete /'ɒbsəliːt/ *adj.*
no longer used, out of date 废弃的；过时的

regulator /'regjʊleɪtə(r)/ *n.*
an instrument for controlling the temperature, speed, etc. of sth. 校准器；调节器

intuition /ˌɪntjuː'ɪʃən/ *n.*
the ability to understand or know sth. because of a feeling rather than by considering the facts 直觉；直觉力

domain /dəʊ'meɪn/ *n.*
a set of possible quantities by which sth. can vary 域

filter /'fɪltə(r)/ *vt.*
to remove unwanted substances from water, air, etc. by passing it through a special substance or piece of equipment 过滤

analogy /ə'nælədʒɪ/ *n.*
sth. that seems similar between two situations or processes 类比

deviation /ˌdiːvɪ'eɪʃən/ *n.*
a noticeable difference from what is expected or acceptable 偏差；误差

prescribed /prɪ'skraɪbd/ *adj.*
set down as a rule or guide 规定的

compressor /kəm'presə(r)/ *n.*
a machine or part of a machine that compresses air or gas 压缩机

hysteresis /ˌhɪstə'riːsɪs/ *n.* 迟滞现象

deadband /'dedbænd/ *n.*
an interval of a signal domain or band where no action occurs 死谱带；死区