Section A

Pre-reading

1 Some common electrical machines and electrical equipment are shown in the following pictures and their names have been given. Match the pictures with their corresponding names.

transformer contactor switch
electric generator electric motor
relay

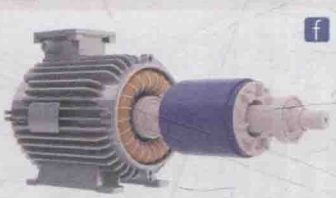
a


b


c


d


e


f

2 Discuss the following questions with your partner.

1. What is the function of an electrical machine? Tell the class the types of electrical machines and their applications that you know.
2. How do you define electrical equipment? List some cases of the use of electrical equipment in our daily life.

Electrical machines, transformers, and daily life

1 An electrical machine is a device that can convert either mechanical energy to electrical energy or electrical energy to mechanical energy. When such a device is used to convert mechanical energy to electrical energy, it is called a generator. When it converts electrical energy to mechanical energy, it is called a motor. Since any given electrical machine can convert power in either direction, any machine can be used as either a generator or a motor. Almost all practical motors and generators convert energy from one form to another through the action of a magnetic field. The transformer is an electrical device that is closely related to electrical machines. Since transformers operate on the same principles as generators and motors, depending on the action of a magnetic field to accomplish the change in voltage level, they are usually studied together with generators and motors. These three types of electric devices are ubiquitous in modern daily life. Electric motors in the home run refrigerators, freezers, vacuum cleaners, blenders, air conditioners, fans, and many similar appliances. In the workplace, motors provide the motive power for

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almost all tools. Of course, generators are necessary to supply the power used by all these motors.

Transformers

2 A transformer is a device that changes AC electric power at one voltage level to AC electric power at another voltage level through the action of a magnetic field. It consists of two or more coils of wire wrapped around a common ferromagnetic core. These coils are (usually) not directly connected. The only connection between the coils is the common magnetic flux present within the core.

3 In a modern power system, electric power is generated at voltages of 12 to 25 kV. Transformers step up the voltage to between 110 kV and nearly 1000 kV for transmission over long distances at very low losses. Transformers then step down the voltage to the 12- to 34.5-kV range for local distribution and finally permit the power to be used safely in homes, offices, and factories at voltages as low as 120 V.

AC machinery fundamentals

4 AC machines are generators that convert mechanical energy to AC electrical energy and motors that convert AC electrical energy to mechanical energy. The fundamental principles of AC machines are very simple, but unfortunately, they are somewhat obscured by the complicated construction of real machines. There are two major classes of AC machines – synchronous machines and induction machines. Synchronous machines are motors and generators whose magnetic field current is supplied by a separate DC power source, while

induction machines are motors and generators whose field current is supplied by magnetic induction (transformer action) into their field windings. The field circuits of most synchronous and induction machines are located on their rotors.

5 In a synchronous generator, a DC current is applied to the rotor winding, which produces a rotor magnetic field. The rotor of the generator is then turned by a prime mover, producing a rotating magnetic field within the machine. This rotating magnetic field induces a three-phase set of voltages within the stator windings of the generator. The term synchronous refers to the fact that this machine's electrical frequency is locked in or synchronized with its mechanical rate of shaft rotation. The synchronous generator is used to produce the vast majority of electric power used throughout the world.

6 Synchronous motors are synchronous machines used to convert electrical power to mechanical power. A synchronous motor is the same physical machine as a synchronous generator, except that the direction of real power flow is reversed. Since synchronous motors are usually connected to power systems containing generators much larger than the motors, the frequency and terminal voltage of a synchronous motor are fixed (i.e. the power system looks like an infinite bus to the motor).

Induction motors

7 In induction machines, the rotor voltage (which produces the rotor current and the rotor magnetic field) is induced in the rotor windings rather than being physically connected by wires. The distinguishing feature of an induction motor is that no DC field current is required to run the machine.

8 Although it is possible to use an induction machine as either a motor or a generator, it has many disadvantages as a generator and so is rarely used in that manner. For this reason, induction machines are usually referred to as induction motors.

9 The induction motor is the most popular type of AC motor because of its simplicity and ease of operation. An induction motor does not have a separate field circuit; instead, it depends on transformer action to induce voltages and currents in its field circuit. In fact, an induction motor is basically a rotating transformer. Its equivalent circuit is similar to that of a transformer, except for the effects of varying speed.

DC machinery fundamentals

10 DC machines are generators that convert mechanical energy to DC electric energy and motors that convert DC electric energy to mechanical energy. Most DC machines are like AC machines in that they have AC voltages and currents within them – DC machines have a DC output only because a mechanism exists that converts the internal AC voltages to DC voltages at their terminals. Since this mechanism is called commutator, DC machinery is also known as commutating machinery.

DC motors and generators

11 DC motors are DC machines used as motors, and DC generators are DC machines used as generators. The same physical machine can operate as either a motor or a generator – it is simply a question of the direction of the power flow through it.

12 There are several types of DC motors, differing in the manner in which their field fluxes are derived. These types of motors are separately excited, self-excited and permanent magnet. The manner in which the flux is derived affects the way it varies with the load, which in turn affects the motor's overall torque-speed characteristic.

13 DC generators are DC machines used as generators. There are several different types of DC generators, differing in the manner in which their field fluxes are

derived. These methods affect the output characteristics of the different types of generators. The common DC generator types are separately excited, shunt, series, cumulatively compounded, and differentially compounded.

14 Today, DC generators have been replaced in many applications by AC power sources and solid-state electronic components. This is true even in the automobile, which is one of the most common users of DC power.

New words and expressions

convert /kən'vɜːt/ *vt.*
to change or make sth. change from one form, purpose, system, etc. to another（使）转变；转换；转化

ubiquitous /juː'bɪkwɪtəs/ *adj.*
seeming to be everywhere or in several places at the same time 普遍存在的；无所不在的

ferromagnetic /ˌferəʊmæg'netɪk/ *adj.*
having the kind of magnetism which iron has 铁磁的；铁磁体的

flux /flʌks/ *n.*
a flow or an act of flowing 通量；流动

synchronous /'sɪŋkrənəs/ *adj.*
happening or existing at the same time 同时发生（或存在）的；同步的；共时的

induction /ɪn'dʌkʃən/ *n.*
the production of electricity in one object by another that already has electrical or magnetic power 电磁感应

three-phase /'θriː'feɪz/ *adj.* 三相的

stator /'steɪtə(r)/ *n.*
a mechanical device consisting of the stationary part of a motor or generator in or around which the rotor revolves（发电机的）定子

shaft /ʃɑːft/ *n.*
a metal bar that joins parts of a machine or an engine together, enabling power and movement to be passed from one part to another（机器的）轴；传动轴

rotor /'rəʊtə(r)/ *n.*
a part of a machine that turns around a central point（机器的）转子；转动部件

commutator /'kɒmjuːteɪtə(r)/ *n.*
a device for changing the direction in which electricity flows（电流）换向器；整流器

commutate /'kɒmjuːteɪt/ *vt.*
to regulate or reverse the direction of (an electric current), especially to make it a direct current 转换（交流电）的方向；将（交流电）整流（尤指变交流电为直流电）

load /ləʊd/ *n.*
the power output of a generator or power plant 发电量

torque /tɔːk/ *n.*
a twisting force that causes machinery, etc. to rotate（使机器等旋转的）转矩

cumulatively /'kjuːmjʊlətɪvli/ *adv.*
in a cumulative manner 累积地；渐增地

differentially /ˌdɪfə'renʃəli/ *adv.*
in a differential manner 区别地

magnetic flux 磁通量

field winding 励磁绕组；磁体绕组

stator winding 定子绕组