МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
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Lesson 1

1. Read and translate the text.

The history of Electricity

Electricity (from the Greek word ηλεκτρον, (elektron), meaning amber, and finally from New Latin *ēlectricus*, «amber-like») is a general term that encompasses a variety of phenomena resulting from the presence and flow of electric charge. These include many easily recognizable phenomena such as lightning and static electricity, but in addition, less familiar concepts such as the electromagnetic field and electromagnetic induction.

In general usage, the word 'electricity' is better identified by more precise terms:

- **Electric charge** – a property of some subatomic particles, which determines their electromagnetic interactions. Electrically charged matter is influenced by, and produces, electromagnetic fields.
- **Electric current** – a movement or flow of electrically charged particles, typically measured in amperes.
- **Electric field** – an influence produced by an electric charge on other charges in its vicinity.
- **Electric potential** – the capacity of an electric field to do work, typically measured in volts.
- **Electromagnetism** – a fundamental interaction between the magnetic field and the presence and motion of an electric charge.

Electricity would remain little more than an intellectual curiosity for millennia until 1600, when the English physician William Gilbert made a careful study of electricity and magnetism, distinguishing the lodestone effect from static electricity produced by rubbing amber. He coined the New Latin word *electricus* to refer to the property of attracting small objects after being rubbed.

In the 18th century, Benjamin Franklin conducted extensive research in electricity, selling his possessions to fund his work. He observed a succession of sparks jumping from the key to the back of his hand, showing that lightning was indeed electrical in nature.

In 1791 Luigi Galvani published his discovery of bioelectricity, demonstrating that electricity was the medium by which nerve cells passed signals to the muscles. Alessandro Volta's battery, or voltaic pile, of 1800, made from alternating layers of zinc and copper, provided scientists with a more reliable source of electrical energy than the electrostatic machines previously used. The recognition of electromagnetism, the unity of electric and magnetic phenomena, is due to André-Marie Ampère in 1819-1820; Michael Faraday invented the electric motor in 1821, and Georg Ohm mathematically analysed the electrical circuit in 1827.

While it had been the early 19th century that had seen rapid progress in electrical science, the late 19th century would see the greatest progress in electrical engineering. Through such people as Nikola Tesla, Thomas Edison, Ottó Bláthy, George Westinghouse, Ernst Werner von Siemens, Alexander Graham Bell and Lord Kelvin, electricity was turned from a scientific curiosity into an essential tool for modern life, becoming a driving force for the Second Industrial Revolution.

2. Answer the questions:

1) Call the main terms of electricity.

2) Who was W. Gilbert? Name his scientific work.

3) How did he explain the word "electricity"?

4) Describe B. Franclin's scientific research.

5) Who were scientists of 19^{th} century?

Lesson 2

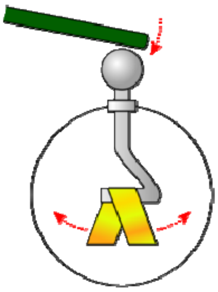
1. Read and translate the text. Find the translations of the underlining words.

Electric charge

Electric charge is a property of certain subatomic particles, which gives rise to and interacts with, the electromagnetic force, one of the four fundamental forces of nature. Charge originates in the atom, in which its most familiar carriers are the electron and proton. Electric charge may be transferred between bodies, either by direct contact, or by passing along a conducting material, such as a wire.

The presence of charge gives rise to the electromagnetic force: charges exert a force on each other, an effect that was known, though not understood, in antiquity. A lightweight ball suspended from a string can be charged by touching it with a glass rod that has itself been charged by rubbing with a cloth. If a similar ball is charged by the same glass rod, it is found to repel the first: the charge acts to force the two balls apart. Two balls that are charged with a rubbed amber rod also repel each other. However, if one ball is charged by the glass rod, and the other by an amber rod, the two balls are found to attract each other. These phenomena were investigated in the late eighteenth century by Charles-Augustin de Coulomb, who deduced that charge manifests itself in two opposing forms. This discovery led to the well-known axiom: like-charged objects repel and opposite-charged objects attract.

The force acts on the charged particles themselves, hence charge has a tendency to spread itself as evenly as possible over a conducting surface. The electromagnetic force is very strong, second only in strength to the strong interaction, but unlike that force it operates over all distances. In comparison with the much weaker gravitational force, the electromagnetic force pushing two electrons apart is 1042 times that of the



gravitational attraction pulling them together.

Charge can be measured by a number of means, an early instrument being the gold-leaf electroscope, which although still in use for classroom demonstrations, has been superseded by the electronic electrometer *(Pic. 1. Charge on a gold-leaf electroscope causes the leaves to visibly repel each other).*

2. Finish the following sentences.

1) Electric charge may be transferred between …. 2) … charges exert a force on each other … . 3) If a similar ball is charged by the same glass rod … . 4) This discovery led to the well-known axiom … . 5) The electromagnetic force is … . 6) In comparison with the much weaker gravitational force … .

3. Find in the text Present Simple Tense.

4. Make up some questions and ask somebody.

Lesson 3

1. Read and translate the text. Make up vocabulary.

Electric current

The movement of electric charge is known as an electric current, the intensity of which is usually measured in amperes. Current can consist of any moving charged particles; most commonly these are electrons, but any charge in motion constitutes a current.

A positive current is defined as having the same direction of flow as any positive charge it contains, or to flow from the most positive part of a circuit to the most negative part. The motion of negatively-charged electrons around an electric circuit, one of the most familiar forms of current. However, depending on the conditions, an electric current can consist of a flow of charged particles in either direction, or even in both directions at once.

Pic.2. An electric arc provides an energetic demonstration of electric current

The process by which electric current passes through a material is termed electrical conduction, and its nature varies with that of the charged particles and the material through which they are travelling. Examples of electric currents include metallic conduction, where electrons flow through a conductor such as metal, and electrolysis, where ions (charged atoms) flow through liquids.

Current causes several observable effects, which historically were the means of recognising its presence. That water could be decomposed by the current from a voltaic pile was discovered by Nicholson and Carlisle in 1800, a process now known as electrolysis. Their work was greatly expanded upon by Michael Faraday in 1833. Current through a resistance causes localized heating, an effect James Prescott Joule studied mathematically in 1840. One of the most important discoveries relating to current was made accidentally by Hans Christian Orsted in 1820, when, while preparing a lecture, he witnessed the current in a wire disturbing the needle of a magnetic compass. He had discovered electromagnetism, a fundamental interaction between electricity and magnetics.

In engineering or household applications, current is often described as being either direct current (DC) or alternating current (AC). These terms refer to how the current varies in time. Direct current, as produced by example from a battery and required by most electronic devices, is a unidirectional flow from the positive part of a circuit to the negative. This flow is carried by electrons, they will be travelling in the opposite direction. Alternating current is any current that reverses direction repeatedly; almost always this takes the form of a sinusoidal wave. Alternating current thus pulses back and forth within a conductor without the charge moving any net distance over time. The time-averaged value of an alternating current is zero, but it delivers energy in first one direction, and then the reverse. Alternating current is affected by electrical properties that are not observed under steady state direct current, such as inductance and capacitance.

2. Answer the questions given below.

1) What is the electric current?
2) In what is measured the electric current?
3) Describe the flow process of positive current.
4) Call one of the most familiar forms of the electric current?
5) What means “conduction”?
6) Give the examples of the electric conduction?
7) Who discovered an “electrolysis”?
8) Who discovered an “electromagnetism”?
9) What is direct current (DC)?
10) What is alternating current (AC)?

3. Find Passive Voice in the sentences.

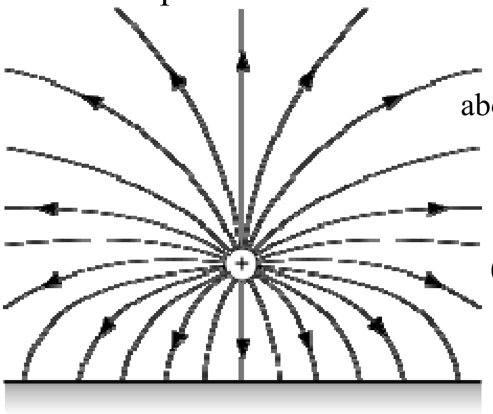
4. Make up the dialogues about: electric current, electrolysis and electromagnetism, direct current and alternating current.

Lesson 4

1. Read and translate the text. Make up vocabulary.

Electric field

The concept of the electric field was introduced by Michael Faraday. An electric field is created by a charged body in the space that surrounds it, and results in a force exerted on any other charges placed within the field. The electric field acts between two charges in a similar manner to the way that the gravitational field acts between two masses, and like it, extends towards infinity and shows an inverse square relationship with distance.



Pic.3. Field lines emanating from a positive charge above a plane conductor

An electric field generally varies in space, and its strength at any one point is defined as the force (per unit charge). As the electric field is defined in terms of force, and force is a vector, so it follows that an electric field is also a vector, having both magnitude and direction. Specifically, it is a vector field.

The study of electric fields created by stationary charges is called electrostatics. The field may be visualized by a set of imaginary lines whose direction at any point is the same as that of the field. This concept was introduced by Faraday, whose term 'lines of force' still sometimes sees use. The field lines are the paths that a point positive charge would seek to make as it was forced to move within the field; they are however an imaginary concept with no physical existence, and the field permeates all the intervening space between the lines. Field lines emanating from stationary charges have several key properties: first, that they originate at positive charges and terminate at negative charges; second, that they must enter any good conductor at right angles, and third, that they may never cross nor close in on themselves.

The field strength is greatly affected by nearby conducting objects, and it is particularly intense when it is forced to curve around sharply pointed objects. This principle is exploited in the lightning conductor, the sharp spike of which acts to encourage the lightning stroke to develop there, rather than to the building it serves to protect.

2. Finish the sentences given below:

1) An electric field is created by … . 2) As the electric field is defined in terms of force and … . 3) The field may be visualized by … . 4) The field lines are the paths that … . 5) This principle is exploited in the lightning conductor … .

3. Make up the questions and ask somebody.

4. Find Passive Voice in the sentences, change them into Active Voice.

5. Give the definitions of the following words: electric field, vector, electrostatics, lightning conductor, force.

Lesson 5

1. **Read and translate the text. Make up vocabulary.**

Electric potential

The concept of electric potential is closely linked to that of the electric field. A small charge placed within an electric field experiences a force, and to have brought that charge to that point against the force requires work. The electric potential at any point is defined as the energy required to bring a unit test charge from an infinite distance slowly to that point. It is usually measured in volts, and one volt is the potential for which one joule of work must be expended to bring a charge of one coulomb. This definition of potential, while formal, has little practical application, and a more useful concept is that of electric potential difference, and is the energy required to move a unit charge between two specified points. An electric field has the special property that it is *conservative*, which means that the path taken by the test charge is irrelevant: all paths between two specified points expend the same energy, and thus a unique value for potential difference may be stated. The volt is so strongly identified as the unit of choice for measurement and description of electric potential difference that the term voltage sees greater everyday usage (Pic.4. A pair of AA cells. The + sign indicates the polarity of the potential differences between the battery terminals).

For practical purposes, it is useful to define a common reference point to which potentials may be expressed and compared. While this could be at infinity, a much more useful reference is the Earth itself, which is assumed to be at the same potential everywhere. This reference point naturally takes the name earth or ground. Earth is assumed to be an infinite source of equal amounts of positive and negative charge, and is therefore electrically uncharged – and unchargeable. Electric potential is a scalar quantity, that is, it has only magnitude and not direction. It may be viewed as analogous to height: just as a released object will fall through a difference in heights caused by a gravitational field, so a charge will 'fall' across the voltage caused by an electric field. As relief maps show contour lines marking points of equal height, a set of lines marking points of equal potential (known as equipotentials) may be drawn around an electrostatically charged object. The equipotentials cross all lines of force at right angles. They must also lie parallel to the object's surface, otherwise this would produce a force on the charge carriers and the field would fail to be static.

The electric field was formally defined as the force exerted per unit charge, but the concept of potential allows for a more useful and equivalent definition: the electric field is the local gradient of the electric potential. Usually expressed in volts per metre, the vector direction of the field is the line of greatest gradient of potential, and where the equipotentials lie closest together.

2. **Make up the questions and ask somebody.**

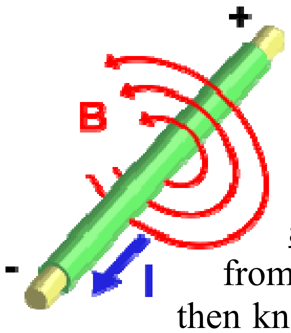
3. **Analyze the Tenses in the text.**

4. **Give the definitions of the words:** electric potential, volt, Earth, equipotentials, scalar quantity, gradient.

Lesson 6

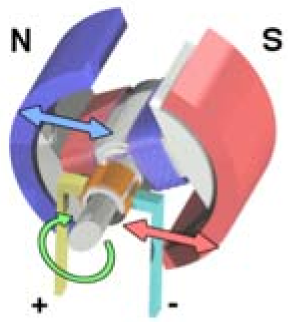
1. **Read and translate the text. Make up vocabulary.**

Electromagnetism



Orsted's discovery in 1821 that a magnetic field existed around all sides of a wire carrying an electric current indicated that there was a direct relationship between electricity and magnetism. Moreover, the interaction seemed different from gravitational and electrostatic forces, the two forces of nature then known. The force also depended on the direction of the current, for if the flow was reversed, then the force did too (Pic. 5. Magnetic field circles around a current).

Ørsted did not fully understand his discovery, but he observed the effect was reciprocal: a current exerts a force on a magnet, and a magnetic field exerts a force on a current. The phenomenon was further investigated by *Ampère*, who discovered that two parallel current-carrying wires exerted a force upon each other. The interaction is mediated by the magnetic field each current produces and forms the basis for the international definition of the ampere.



Pic.6. The electric motor exploits an important effect of electromagnetism: a current through a magnetic field experiences a force at right angles to both the field and current

This relationship between magnetic fields and currents is extremely important, for it led to Michael Faraday's invention of the electric motor in 1821. Faraday's homopolar motor consisted of a permanent magnet sitting in a pool of mercury. A current was allowed through a wire suspended from a pivot above the magnet and dipped into the mercury.

Experimentation by Faraday in 1831 revealed that a wire moving perpendicular to a magnetic field developed a potential difference between its ends. Further analysis of this process, known as electromagnetic induction, enabled him to state the principle, now known as Faraday's law of induction, that the potential difference induced in a closed circuit is proportional to the rate of change of magnetic flux. Exploitation of this discovery enabled him to invent the first electrical generator in 1831.

Faraday's and Ampère's work showed that a time-varying magnetic field acted as a source of an electric field, and a time-varying electric field was a source of a magnetic field. Thus, when either field is changing in time, then a field of the other is necessarily induced. Such a phenomenon has the properties of a wave, and is naturally referred to as an electromagnetic wave. Electromagnetic waves were analysed theoretically by *James Clerk Maxwell* in 1864.

2. Make up some questions and ask somebody.

3. Choose the right answer for the following questions:

1) What was Orsted's discovery in 1821?
2) What did the force depend on?
3) What did Orsted observe?
4) When does each current produce and form the basis?
5) What was M. Faraday's invention in 1821?
6) What was developed by a wire moving perpendicular to a magnetic field?
7) Describe the main principle of induction law.

1) Orsted observed the effect of force.
2) That was invention of the electric motor.
3) That was invention of a magnetic field.
4) A potential difference between the ends of wire was developed.
5) The interaction is mediated by the magnetic field each current produces and forms the basis.
6) The force depended on the direction of the current.
7) The potential difference induced in a closed circuit is proportional to the rate of change of magnetic flux.

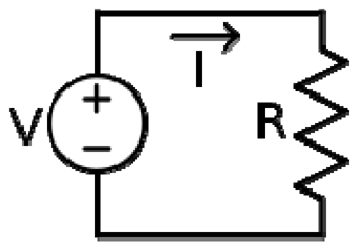
4. Make up the plan and retell the text.

Lesson 7

1. **Read and translate the text. Make up vocabulary of underlining words.**

Electric circuits

An electric circuit is an interconnection of electric components.



The components in an electric circuit can take many forms, which can include elements such as resistors, capacitors, switches, transformers and electronics. Electronic circuits contain active components, usually semiconductors, and typically exhibit non-linear behavior, requiring complex analysis. The simplest electric components are those that are termed passive and linear: while they may temporarily store energy, they contain no sources of it, and exhibit linear responses to stimuli.

Pic. 7. A basic electric circuit. The voltage source *V* on the left drives a current *I* around the circuit, delivering electrical energy into the resistance *R*. From the resistor, the current returns to the source, completing the circuit.

The resistor is perhaps the simplest of passive circuit elements: as its name suggests, it resists the current through it, dissipating its energy as heat. The resistance is a consequence of the motion of charge through a conductor: in metals, for example, resistance is primarily due to collisions between electrons and ions. Ohm's law is a basic law of circuit theory, stating that the current passing through a resistance is directly proportional to the potential difference across it. The resistance of most materials is relatively constant over a range of temperatures and currents; materials under these conditions are known as 'ohmic'. The ohm, the unit of resistance, was named in honour of Georg Ohm.

The capacitor is a device capable of storing charge, and thereby storing electrical energy in the resulting field. It consists of two conducting plates separated by a thin insulating layer. A capacitor connected to a voltage supply initially causes a current as it accumulates charge; this current will however decay in time as the capacitor fills, eventually falling to zero. A capacitor will therefore not permit a steady state current, but instead blocks it.

The inductor is a conductor, usually a coil of wire, that stores energy in a magnetic field in response to the current through it. When the current changes, the magnetic field does too, inducing a voltage between the ends of the conductor. The induced voltage is proportional to the time rate of change of the current. The constant of proportionality is termed the inductance. The unit of inductance is the henry, named after Joseph Henry, a contemporary of Faraday. One henry is the inductance that will induce a potential difference of one volt if the current through it changes at a rate of one ampere per second.

2. Finish the following sentences:

1) An interconnection of electric components is … .
2) An electric circuit includes elements such as … .
3) The simplest electric components are … .
4) The resistance is a consequence of … .
5) Ohm's law is a basic law of circuit theory … .
6) The capacitor is a device … .
7) A capacitor connected to a voltage … .
8) …. not permit a steady state current … .
9) When the current changes … .
10) The unit of inductance is the henry … .

3. Find the correct definition.

1) One of the simplest of passive circuit elements: it resists the current through it (capacitor, resistor).
2) The unit of resistance (ampere, ohm, henry).
3) The device that capable of storing charge (capacitor, resistor).
4) The device that stores energy in a magnetic field (conductor, resistor, inductor).
5) The constant of proportionality (inductance, circuit, capacitor).

4. Sign the main idea and retell about:

- Resistance;
- The capacitor;
- The inductance.

Additional texts

Electrical energy

Electrical energy is usually generated by electro-mechanical generators driven by steam produced from fossil fuel combustion, or the heat released from nuclear reactions; or from other sources such as kinetic energy extracted from wind or flowing water. Such generators bear no resemblance to Faraday's homopolar disc generator of 1831, but they still rely on his electromagnetic principle that a conductor linking a changing magnetic field induces a potential difference across its ends. The invention in the late nineteenth century of the transformer meant that electricity could be generated at centralised power stations, benefiting from economies of scale, and be transmitted across countries with increasing efficiency. Since electrical energy cannot easily be stored in quantities large enough to meet demands on a national scale, at all times exactly as much must be produced as is required. This requires electricity utilities to make careful predictions of their electrical loads, and maintain constant co-ordination with their power stations. A certain amount of generation must always be held in reserve to cushion an electrical grid against disturbances and losses.

Demand for electricity grows with great rapidity as a nation modernises and its economy develops. The United States showed a 12% increase in demand during each year of the first three decades of the twentieth century, a rate of growth that is now being experienced by emerging economies such as those of India or China. Historically, the growth rate for electricity demand has outstripped that for other forms of energy. Environmental concerns with electricity generation have led to an increased focus on generation from renewable sources, in particular from wind- and hydropower. While debate can be expected to continue over the environmental impact of different means of electricity production, its final form is relatively clean.

Electricity is an extremely flexible form of energy, and has been adapted to a huge, and growing, number of uses. The invention of a practical incandescent light bulb in the 1870s led to lighting becoming one of the first publicly available applications of electrical power. Although electrification brought with it its own dangers, replacing the naked flames of gas lighting greatly reduced fire hazards within homes and factories. Public utilities were set up in many cities targeting the burgeoning market for electrical lighting.

The Joule heating effect employed in the light bulb also sees more direct use in electric heating. While this is versatile and controllable, it can be seen as wasteful, since most electrical generation has already required the production of heat at a power station. A number of countries, such as Denmark, have issued legislation restricting or banning the use of electric heating in new buildings. Electricity is however a highly practical energy source for refrigeration, with air conditioning representing a growing sector for electricity demand, the effects of which electricity utilities are increasingly obliged to accommodate.

Electricity is used within telecommunications, and indeed the electrical telegraph, demonstrated commercially in 1837 by Cooke and Wheatstone, was one of its earliest applications. With the construction of first intercontinental, and then transatlantic, telegraph systems in the 1860s, electricity had enabled communications in minutes across the globe. Optical fibre and satellite communication technology have taken a share of the market for communications systems, but electricity can be expected to remain an essential part of the process.

The effects of electromagnetism are most visibly employed in the electric motor, which provides a clean and efficient means of motive power. A stationary motor such as a winch is easily provided with a supply of power, but a motor that moves with its application, such as an electric vehicle, is obliged to either carry along a power source such as a battery, or by collecting current from a sliding contact such as a pantograph, placing restrictions on its range or performance.

Electronic devices make use of the transistor, perhaps one of the most important inventions of the twentieth century, and a fundamental building block of all modern circuitry. A modern integrated circuit may contain several billion miniaturised transistors in a region only a few centimetres square.

Electrical phenomena in nature

Electricity is not a human invention, and may be observed in several forms in nature, a prominent manifestation of which is lightning. Many interactions familiar at the macroscopic level, such as touch, friction or chemical bonding, are due to interactions between electric fields on the atomic scale. The Earth's magnetic field is thought to arise from a natural dynamo of circulating currents in the planet’s core. Certain crystals, such as quartz, or even sugar, generate a potential difference across their faces when subjected to external pressure. This phenomenon is known as piezoelectricity, from the Greek *piezein* (πιέζειν), meaning to press, and was discovered in 1880 by Pierre and Jacques Curie. The effect is reciprocal, and when a piezoelectric material is subjected to an electric field, a small change in physical dimensions take place.

Some organisms, such as sharks, are able to detect and respond to changes in electric fields, an ability known as electroreception, while others, termed electrogenic, are able to generate voltages themselves to serve as a predatory or defensive weapon. The order Gymnotiformes, of which the best known example is the electric eel, detect or stun their prey via high voltages generated from modified muscle cells called electrolytes. All animals transmit information along their cell membranes with voltage pulses called action potentials, whose functions include communication by the nervous system between neurons and muscles. An electric shock stimulates this system, and causes muscles to contract. Action potentials are also responsible for coordinating activities in certain plants and mammals.

Electricity in popular culture

In the 19th and early 20th century, electricity was not part of the everyday life of many people, even in the industrialised Western world. The popular culture of the time accordingly often depicts it as a mysterious, quasi-magical force that can slay the living, revive the dead or otherwise bend the laws of nature. This attitude is manifest in Mary Shelley’s *Frankenstein* (1819), which originated the cliché of a mad scientist reviving a patchwork creature with electrical power.

As the public familiarity with electricity as the lifeblood of the Second Industrial Revolution grew, its wielders were more often cast in a positive light, such as the workers who "finger death at their gloves' end as they piece and repiece the living wires" in Rudyard Kipling's 1907 poem *The Sons of Martha*. Electrically powered vehicles of every sort featured large in adventure stories such as those of Jules Verne or the *Tom Swift* books. The masters of electricity, whether fictional or real—including scientists such as Thomas Edison, Charles Steinmetz or Nikola Tesla—were popularly conceived of as having wizard-like powers.

With electricity ceasing to be a novelty and becoming a necessity of everyday life in the later half of the 20th century, it required particular attention by popular culture only when it *stops* flowing, an event that usually signals disaster. The people who *keep* it flowing, such as the nameless hero of Jimmy Webb’s song "Wichita Lineman" (1968), are still often cast as heroic, wizard-like figures.

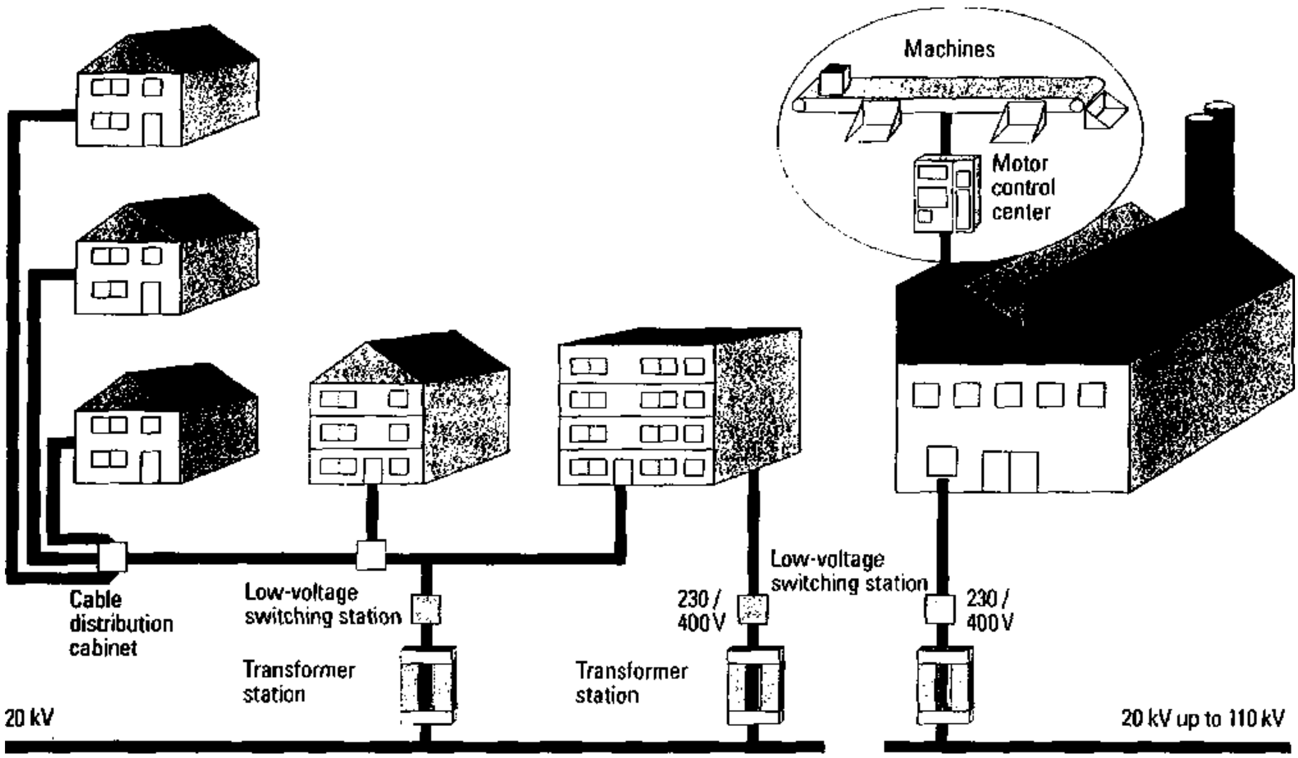
Planning and design of electrical distribution systems in buildings
Structural design

The purpose of electrical installations in buildings is to supply and distribute power. Buildings that are used for different purposes have different requirements in this respect. For this reason, the structure of the buildings must be known before the power supply and distribution systems can be planned and designed.

Figures 1.1/1 to 1.1/4 illustrate the basic forms of these systems in buildings that are used for different purposes.

Fig. 1.1/1 shows the basic structure of the power supply system for *industrial, functional* and *residential* buildings.

Residential buildings ***Functional buildings*** ***Industrial***



buildings

Industrial and functional buildings are usually supplied with electrical energy from an electricity generation (e.g.) system; the supply voltage for the distribution system is generated via transformers in this case. The transformer station required for this purpose is usually part of the owner's system. A utilities substation with switching, protection and measuring equipment must also be provided for the public utility.

In the case of *residential buildings,* the public utility provides the supply voltage for the distribution systems via separate transformer stations. Each residential building is connected to the power supply system via a low voltage cable.

Industrial functional buildings

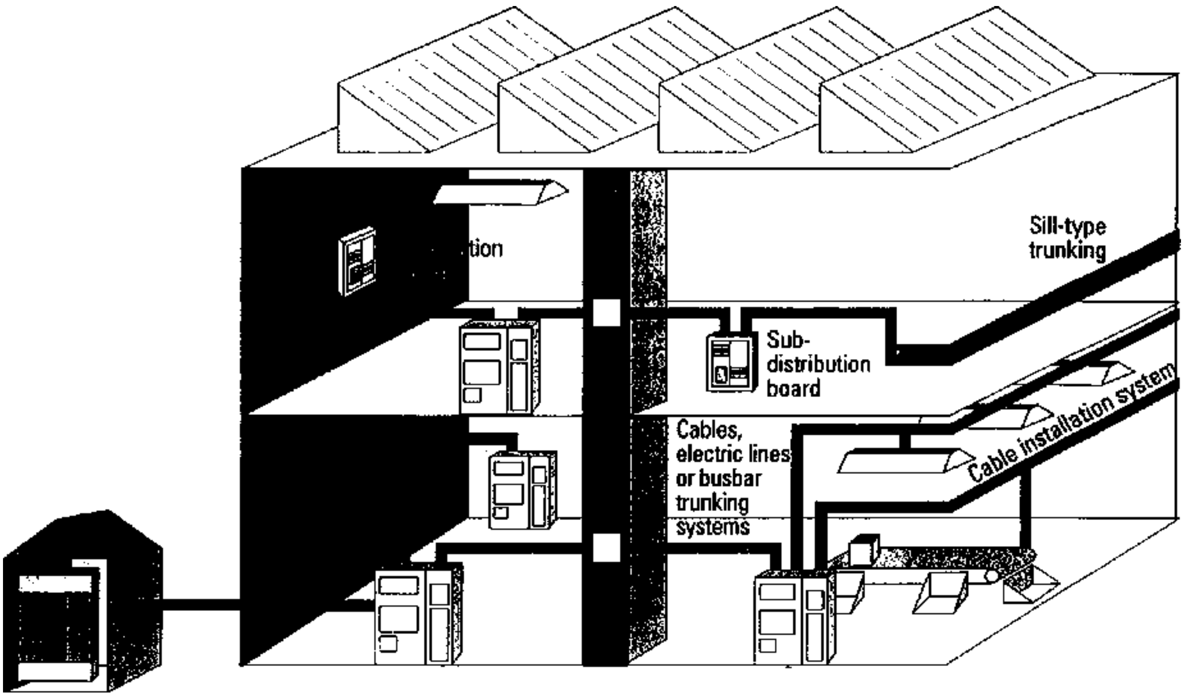
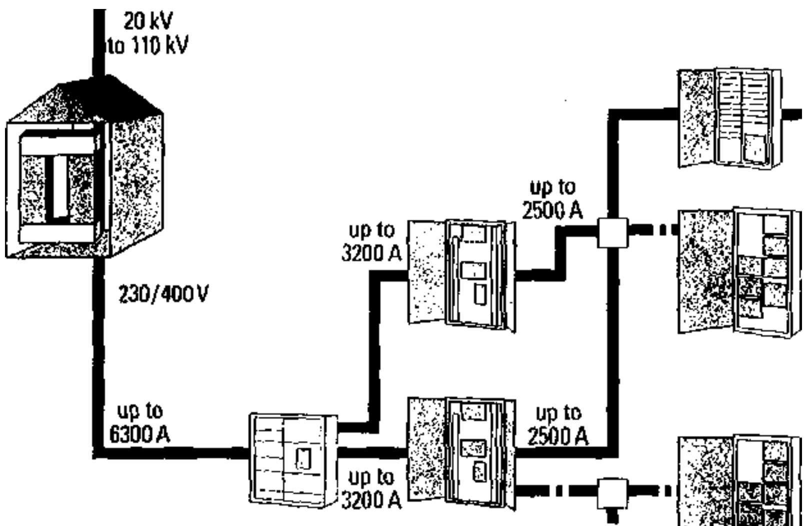


Fig. 1.1/2 shows the most important components that are required for distributing power in an industrial or functional building.

Fig. 1.1/3 shows these components again at the three **distribution levels**:

main distribution level ***sub-distribution level*** ***load level***



Power is thus supplied to the electrical loads via the low-voltage switching station, main distribution board, sub-distribution board and small distribution board by means of a low voltage, e.g. 230/400 V. The electrical connections between these components are established via different cables and electric lines as well as busbar trunking and installation systems.

The power distribution components are classified on the basis of the relevant current intensities at each power distribution level. At the *main distribution level,* SIVACON low-voltage switchboards are used for up to 6300 A and SIKUS or STRATUM modular distribution boards for up to 3200 A.

Main distribution boards are used first and foremost for: 1) safety disconnection; 2) coupling busbar sections; 3) protecting busbars; 4) selectivity vis-a-vis upstream protection equipment

They are primarily equipped with: 1) circuit-breakers and non-automatic circuit-breakers; 2) the circuit-breakers and 3) fuses.

At the **sub-distribution level**, permanently-installed STAB, SIKUS and SIPRO floor-mounting distribution boards are used for up to 2500 A.

These distribution boards are used for: 1) safety disconnection; 2) switching electrical loads, e.g. lighting; 3) systems and motors; 4) protecting cables, electric lines and loads; 5) back-up protection and selectivity vis-à-vis upstream and downstream protection equipment; 6) overvoltage protection; 7) control, metering and measuring purposes.

The following devices are integrated in the distribution boards on order to carry out these functions: circuit-breakers, switch-disconnectors; miniature circuit-breakers; fuses; modular built-up equipment for control, metering and measuring purposes.

STAB wall-mounting distribution boards and SIMBOX 63 small distribution boards are mainly used at the load level. These distribution boards are used for: protecting persons and property; protecting electrical loads; protecting cables and electric lines; overvoltage protection; safety disconnection; monitoring and signalling; open and closed-loop control; metering, measuring and display purposes.

The following devices are integrated in the distribution boards in order to carry out these functions: circuit breakers, swith-disconnectors and fuse swith-disconnectors, residual-current devices, miniature circuit breakers, fuse systems, earth-leakage monitors, mechanical, electromechanical and electronic built-in devices, time switches, instabus EIB components.

Fig. 1.1/4 shows the basic structure of the distribution levels in residential buildings. Once the power has been supplied by the public utility, only two levels are relevant here, namely the main distribution and load level. This is due to the fact that the main distribution boards and sub-distribution boards are usually combined to form one power distribution level in residential buildings which is referred to as a meter distribution board.

instabus EIB

Figures 1.1/3 and 1.1/4 illustrate how the instabus EIB (European Installation Bus Systems) is implemented at the lead level. Unlike conventional installation systems, instubes offers key benefits in that it simplifies cable installation while, at the same time, supporting a wide range of functions and applications.

Planning fundamentals

Objectives

The purpose of the planning stage is to determine the most suitable electrotechnical infra-structure for the type of building concerned. This infrastructure must satisfy the technical requirements for the respective power supply and the applicable standards. It must, however, also be possible to erect and operate the infrastructure economically. The electrical equipment, such as transformers, switch-gear, cables and conductors, as well as control and monitoring devices, must be dimensioned and selected such that it represents a cost-effective and state-of-the art solution both when considered in terms of individual components and a complete systems. The electrotechnical infrastructure should, therefore, be selected and dimensioned in line with the principles of system engineering, i.e. where preference is given to compatible products from one manufacturer. This electrical equipment must be sufficiently dimensioned to cope with the loads encountered both under normal operating conditions and in the event of a fault.

Standards

Electrical power-supply systems must always be planned, erected, and operated in compliance with recognized codes of practice and technical regulations which are defined in national, European, and international standards. These form the basis for safe operation of the electrical installations and specify minimum requirements for the technical data of the equipment and its fields of application. Compliance with these standards ensures the safety of personnel and installations. In Germany, these are the standards published by DIN VDE which, in the CENELEC member states, correspond to the European Standards (EN). As a result of harmonization, these documents are identical to international standards (IEC publications), with the exception of agreed amendments.

Deviations from these standards are permissible in certain cases if the same degree of safety can be achieved by different means. It is, however, often difficult to verify this. Additional provisions beyond the requirements specified in these standards may be necessary if the safety of personnel and of the installations require this or if these are prescribed by legal requirements, directives, or contracts.

These include: 1) national legal requirements; 2) legal requirements specified by the European Union (EU); 3) accident prevention regulations of trade associations; 4) requirements laid down by building and property insurance companies; technical supply conditions of the local public utility; conditions imposed by authorities responsible for certain operating plants; special requirements of subsequent users (described in the contract or specifications).

Important directives for EU member states are: machine directive, EEMC directive, low-voltage directive, telecommunications terminal directive.

Integrated Planning

Early cooperation between the electrical system planner and the architects, specialist planners, different trades, the responsible public utility, and the purchasing authorities is essential during the project definition and integrated planning stages.

The following points must be clarified here: 1) type, use, and form of the buildings (residential, functional, industrial, high-rise, low-profile, number of storeys, etc.) as well as their location to allow the demarcation of individual supply zones;

2) standards and conditions imposed by the building authorities with regard to the erection of the installation and permit-granting procedures; 3) connection queries and conditions of the responsible public utility. These determine the supply voltage (high or low-voltage), the design of the public utility's substation, as well as the measuring and metering equipment. They also influence dimensioning of the installation, e.g. power system protection (starting currents, grading times); 4) declaration of power requirements, rates, and connection charges; 5) determination of the building-related connected loads based on specific surface-area loading in accordance with the use of the building for different project stages; 6) determination of load centers, possible supply routes, and locations for transformers, main switching stations, and distribution systems; 7) requirements for necessary emergency power-supply systems and/or UPS systems with regard to the permissible interruption times, and for additional safety supply systems.

Building system engineering

The requirements regarding a modern, upgradeable electrotechnical building infrastructure can only be fulfilled with systems which intelligently link the different trades in the building. Building system engineering, however, changes the design and layout of the electrical power-supply systems in the building and affects planning and project design procedures.

Functional, low-cost solutions should, therefore, take account of the following general requirements vis-à-vis the electrical power supply bearing in mind the needs of the user: 1) transparent, uncomplicated system design to facilitate system management; 2) simple adaptation to changing utilization and operational conditions; 3) installations with high degree of supply and operational reliability, even if individual components fail (back-up systems, emergency power-supply systems, selectivity of the power-system protection, high degree of availability); 4) high level of supply quality, i.e. low voltage fluctuations caused by load changes with sufficient voltage symmetry and harmonic loads.

Effect of building system engineering

Nowadays, a large number of different automation, monitoring and control tasks have to be performed in practically every type of building, be this residential, functional, or industrial. These tasks include: 1) heating, air-conditioning, and ventilation control; 2) building security with intruder detection, fire alarm, and access control systems, lighting, roller blind shutters, and blind control; 3) load monitoring and load management.

In the past, several transmission systems, in addition to the power-supply and distribution systems, were installed in order to deal with the individual tasks. This, coupled with the increasing complexity of modern communications technology, resulted in complicated, costly solutions which increased expenditure even at the project planning stage. The power transmission routes and the devices for controlling them are usually linked in these building concepts which means that the intended use of the area in question must be known at the project definition stage.

Nowadays, building system engineering with instabus EIB is used for buildings with high utility value. The actuators and sensors in the instabus system use the same transmission route. Leading manufacturers have opted for building system engineering equipment based on the **E**uropean **I**nstallation **B**us. This technology relieves the electrical power transmission systems of control and monitoring tasks. They can, therefore, be dimensioned according to the technical and cost-related requirements of power transmission alone. The cable routes between the distribution boards and loads are shorter. It is often possible to install cables and conductors with smaller cross sections or to use the existing circuits more efficiently with regard to the ratio of maximum load current to rated current. Both reduce the number and complexity of cables and conductors and, therefore, the fire load for the useful floor areas.

Busbar trunking systems are being used to an increasing extent both for the primary power supply between low voltage main switchgear and storey or sub-distribution boards, and for supplying power to the load circuit. The power distribution systems for a supply section are dimensioned according to the requirements defined for the intended use and for subsequent changes in the usage of the building. It is, therefore, no longer necessary to know the precise location of the useful floor areas. The percentage of overall utilization is often all that is required to dimension the power demand and, in turn, the power transmission equipment based on surface-area loads. Frequent re-planning, which costs both time and money, is therefore avoided.

In the case of monitoring and control systems, the sensors are not assigned to the actuators and to the loads to be monitored and controlled until commissioning stage. The appropriate **EIB tool software** is used for this purpose.

Cross installation system integration

Information from the individual installations is exchanged via the same transmission route. Information from the building monitoring system, e.g. window "open" or "closed", can be used to control heating and air-conditioning system in individual rooms, and blind "up" or "down" to save energy by switching off lighting rows at windows. An access control system can monitor personnel leaving and entering buildings or sections of buildings. At the same time, this information can be used to save energy, e.g. lights/computers/heating "on" or "off", or to activate security equipment such as room monitoring devices, intruder detection systems, etc.

Design of building networks

The configuration of low-voltage distribution systems in a complex building and for individual supply areas depends on the following factors and requirements: 1) level of power demand (determines the voltage level for the power supplied by the public utility); 2) structure of supply area, e.g. density (low and/or high), building type (low-profile, high-rise) and purpose; 3) size, number, and physical location of the load centers in individual supply areas; 4) possible arrangements of the transformers and associated low-voltage main distribution boards; 5) possible routing for the main distribution system, 6) general and special requirements of the investor and subsequent user with regard to: supply reliability and supply quality, low investment costs and high cost-effectiveness during operation.

When configuring building power systems, it is important not just to choose the most cost-effective equipment to be used in the building but to find the best possible overall solution – both from a technical and cost-related point of view – not only for the point in time at which the building is erected but also the total service life of the building.

General power supply

Small building power systems with a power requirement of up to 200 kW-300 kW are usually supplied from the low-voltage distribution systems of the public utility. Special-tariff customers, such as hospitals, large hotels, administrative buildings, banks, large computer centers, sports stadiums, research institutes, universities, airports, industrial plants, etc. with a high power demand are supplied from the e.g. system of the utility via transformer substations.

A ring feeder cable, to which other customers are connected, is frequently used for power demand of up to 1.5 MW. With power demands in excess of 1.5 MW, the power is usually supplied directly from the nearest public utility transformer substation via special cables.

If power is supplied from the high-voltage system, the buildings are provided with a transformer substation with the public utility infeed, main circuit-breaker, metering equipment (sequence is determined by the public utility), transformer feeders and, if the power system of the special-tariff customers is particularly large, additional cable feeders to satellite substations.

Low-cost switchpanels with switch disconnectors and high-voltage high-breaking-capacity fuses are used for connecting the transformers in systems with a rated output of up to 800 kVA. Circuit-breakers with secondary relays must be provided for higher rated outputs and short-circuit current loads of 16 kA to 20 kA.

In addition to the lower cost for the high-voltage switchgear, the use of switch-disconnectors with high-voltage high-breaking-capacity (h. v. h. b. c.) fuses instead of circuit-breakers also has the following benefits: 1) the voltage dip caused by short-circuit-type faults downstream of fuses is very small. With circuit-breakers, however, a voltage dip of almost 100% and load disturbance must be expected within the short-circuit clearance time; 2) the energy released in the event of a short-circuit is dampened considerably by the current-limiting effect of the fuse and the associated short clearance times. Connecting cables with the smallest commercially available cross section (approximately 25mm^2 with 10kV and 20 kV) can, therefore, usually be installed.

With circuit-breakers, the cross sections must normally be dimensioned according to the required short-circuit strength (e.g. minimum cross section 95 mm^2). If circuit-breakers are used, vent outlets must be provided for the transformer and switch-gear rooms. The advantages of using circuit-breakers include less complicated system management (no fuses need to be changed), simpler configuration and the high number of switching cycles between maintenance inspections.

Both the inrush current of the transformers and the starting frequency are crucial factors in determining the smallest permissible high-voltage high-breaking capacity fuse. The lowest short-circuit current that occurs on the low-voltage side of the transformer which must be disconnected in the event of a fault is used to determine the largest permissible (h. v. h. b. c.) fuse. The area to be supplied with power by a transformer (expansion and surface-area loading) and the reserve power to be provided is a transformer fails determine the rated output to be selected for the transformer.

Transformers with a rated output of between 400 kVA and 1000 kVA are usually selected for the surface-area loads encountered nowadays. More powerful transformers of up to approximately 3.5 MVA are used especially in industrial buildings with a particularly high load density or large individual loads. Depending on the required level of supply reliability (partial or full reserve, instantaneous reserve) the necessary transformer out put is divided into several smaller units which can be operated either in parallel or individually. The required reserve power increases with the rated output of the transformers. This results in a lower capacity utilization of the transformers under normal operating conditions.

The total output of transformers operating parallel to each other and feeding power into an low-voltage system is restricted with respect to the short-circuit current load. In the case of parallel infeeds the short-circuit currents in the outgoing feeder panels are always higher than those in the individual incoming feeder panels or coupler units between the infeeds. The equipment in the infeeds and coupler units can be configured for a short-circuit current load from a specific number of parallel transformers.

The Stages of Writing a Paper

First, the topic, subject or question should be thought about carefully: what is required in the paper should be under stood. Then a note should be made of ideas, perhaps from knowledge or experience. After this, any books, journals, etc. should be noted that have been recommended, perhaps from a reading list or a bibliography. Then to the list should be added any other books, articles, etc. that are discovered while the recommended books are being found.

Now is the time for the books, chapters, articles, etc to be read with a purpose, by appropriate questions being asked that are related to the paper topic or title. Clear should be written from the reading. In addition, a record of the sources should be kept so that a bibliography or list of references can be compiled at the end of the paper. Any quotation should be accurately acknowledged: author's surname and initials, year of publication, edition, publisher, place publication, and page numbers of quotations.

When the notes have been finished they should be looked through in order for an overview of the subject to be obtained. Then the content of the paper should be decided on and how it is to be organized or planned. The material should be carefully selected: there may be too much and some may not be relevant to the question. The material, or ideas, should be divided into three main sections for the paper: the introduction, the main body, and the conclusion. An outline of the paper should be written, with use being made of headings or subheadings, if they are appropriate.

The first draft should be written in a suitable formal style. While doing this, the use of colloquial expressions and personal references should be avoided. When it had been completed the draft should be read critically, and in particular, the organization, cohesion, and language should be checked. Several questions should be asked about it, for example: Is it clear? Is it concise? Is it comprehensive? Then the draft should be revised and the final draft written – legibly! It should be remembered that first impressions are important.

Finally, the bibliography should be compiled, using the conventional format: the references should be in strict alphabetical order. Then the bibliography should be added to the end of the paper.

Incorporating quotations in writing

Verbs and phrases that can be used to introduce quotations in writing:

- As X observed/ pointed out/ suggested/ noted/ indicated '…'
- According to X, '…'
- For example, X argued that '…'
- X suggests that '…'
- The need for it is widely recognized: '…'
- Writing in 2007, X commented that '…'
- To quote X: '…'
- Recent research by X shows that '…'

Exemplification

for example
shown (exemplified, illustrated) by …
X shows (exemplifies, illustrates) this
the following examples
the following are examples of X: …
a and b are examples of X
writers such (such writers) as Dickens and Hardy …

Qualification of comparison

to be considerably (a great deal, very much, quite a lot, rather, somewhat, a little, slightly, scarcely, hardly, only just) smaller (bigger, cheaper…) than …

to be exactly (precisely, just, virtually, practically, more or less, almost, nearly, approximately, about) the same as …

to be exactly (entirely, quite) the same as …

to be totally (completely, entirely, quite) different from …

to be not quite as/so big (expensive, dear, etc.) as …

to be different (dissimilar) in every way (respect)

to be totally (completely, entirely, quite) different

Cause and Effect

Therefore, so, as a result, accordingly, consequently, because of this, thus, hence, to cause to result in, to lead to, to produce

Caution
It appears to/that
It would appear to/that
It seems to/that
It would seem to/that
It tends to be
There is a tendency to/for
It is said that
It has been suggested that
It is generally agreed that
It is widely accepted that
It is generally recognized that
Marking Stages in a Discussion
First, firstly, first of all, in the place, the most important…
Second, secondly, in the second place, the next most important…
Next, that, after this/that, following this/that…
Finally, lastly, in conclusion…

Paragraphs

Besides making sure that the *logical* threads which bind a text together are intact, writers also have to weave various strands of ideas and information into a coherent *linguistic* fabric of sentences and paragraphs.

The material must be presented in logical order and clear language. A paper consists of a number of paragraphs. Here are some hints of paragraph writing: 1) There are paragraph introducers which are sentences that establish the topic or focus of the paragraph as a whole. The topic sentence in the paragraph contains a key idea. 2) The are paragraph developers which present examples or details of various kinds to support the ideas of the sentence. 3) There are sometimes viewpoints or context modulators, which are sentences that provide a smooth transition between different sets of ideas. 4) There are paragraph terminators or restatement sentences, which logically conclude the ideas discussed in the paragraph.

To be able to write a good paper you must realize that your paper should be relevant to the set topic in both content and focus; the paper should be the result of wide reading, taking notes, looking things up, sorting out information, theories and ideas, and coming to well-thought-out conclusions…

A paper consists of a number of paragraphs which may be sorted into functional groups such as introductory, developmental, transitional, summarizing.

Depending upon the purpose or intent of the writer, particular paragraphs may be thought of as aiming to persuade, inform, argue, or excite. Paragraphs may be also be classified according to such techniques development as comparison, contrast, description, classification, generalization, etc.

In linking paragraphs together the transitional devices may be the paragraphs following: 1) the use of a pronoun instead of the above-mentioned nouns;

2) repetition of the key word or phrase used in the preceding paragraph; 3) the use of transitional words or phrases and connectives.

Connections

All writing, no matter how humble, is consciously created, and results from complex cognitive processes involving translation of non-linear thought into linear written language. Of course, some kinds of writing are clearly more spontaneous than others: a note left for a friend who was out when you called to visit, for instance, will obviously require far less conscious effort to write than will an academic paper written for a degree supervisor. Yet no written text is an entirely random collection of words and information. The writer inevitably imposes some sort of order upon the various elements which make up the text, and is therefore responsible for making sure that the connections – both logical and linguistic – between these elements have been made clear to the reader.

To translate amorphous thought into structured language successfully, we have to make sure that the train of thought which is perfectly clear to us *in our head* is equally clear to the reader *on the page*. The focus in this unit is on:

a) testing out whether logical links between ideas are clear
b) considering linguistic devices available to writers to make logical connections clear to readers.

The following connectives and transitional phrases are particularly useful in paper writing: *first, second, etc.; next, finally, eventually, furthermore, meanwhile; because of, and so; at the same time, but; and (in order) to, so (that); and for, yet, nevertheless, however; where as, while; on the other hand; in contrast, unlike; similarly, also, too; obviously;* etc.

Connectives' chart prototype

<table>
<tr><td rowspan="4">nd</td><td>Listing
Cataloguing
e.g. First,...
Another.
Finally,..</td><td>Adding to what has gone before Reinforcing
e.g. Also Equating
Moreover,... e.g. ... too
Furthermore,... Equally.</td></tr>
<tr><td colspan="2">Transition, leading to a new stage in sequence, or digression
e.g. As for. . .
With reference to . . .
Incidentally, . . .</td></tr>
<tr><td colspan="2">Summing up what has gone before
e.g. In short, . . .
Briefly, .</td></tr>
<tr><td colspan="2">Referring backwards or forwards to similar ideas/references
e.g. That is to say,...</td></tr>
</table>

	For example,...	
	Expressing results or consequences e.g. Therefore,... Accordingly,...	
	Inferring from a previous statement e.g. In other words,... Otherwise, ... If... then...	
r	Expressing in a different, but similar way e.g. Rather,... Or...	
	Expressing an alternative e.g. Alternatively,... On the other hand,..	
ut	Contrasting e.g. By contrast,... On the one hand… on the other… Whereas...	Contradicting On the contrary. In fact, though,.
	Conceding e.g. However,... Although... Nevertheless,…	
or	Expressing reason e.g. Since... Because...	

Restrictions upon the vocabulary

In paper writing the following hints concerning the language may be helpful: 1) restrictions upon the vocabulary. Word and phrases labeled colloquial, familiar, vulgar, slang are excluded as inappropriate. Contracted verbal forms and colloquial abbreviations of words (such as *ad, vac, exam*, etc.) should not be used; 2) wide use of phrasal verbs should be made; 3) scientific style clichés should be used; 4) idioms should be avoided; 5) features of scientific style should be preserved: lengthier or more complex paragraphs; the approach to the material is analytical, objective, intellectual, polemical; the writer's tone is serious, impersonal, formal rather than conversational, personal, colloquial; the writer makes frequent use of passive forms of the verbs; impersonal pronouns and phrases; complex sentence, structures; specialized vocabulary; 6) one must be aware that there are differences in style and usage between disciplines and topics set.

CREATIVE WORK

1. Write a paragraph for the following paper headlines: Building system engineering, Busbar tranking system, General power supply, Integrated planning. Observe the rules of paragraph writing.

2. Write some paragraphs of the paper on your own specialized subject. Before you begin, make notes on some aspects of the subject. Compare and make qualified generalizations, where necessary. Try to give reasons for your own view at the end. Bear in mind that a paragraph normally consists of several sentences but they are all concerned with the theme contained in the topic or key sentence. The key sentence is usually the first one, which reveals the main idea or topic. The other sentences support it by adding further information or examples. A paragraph is self-contained but should link logically with the previous and following paragraphs so that the flow and cohesion of the writing is maintained. The expressions from the table p. 23-24 will help you.

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АНГЛИЙСКИЙ ЯЗЫК

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