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Английский язык

для энергетических специальностей

Учебное пособие
по английскому языку

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Учебное пособие содержит англоязычные технические тексты по механике, молекулярной физике и электричеству. Цель пособия – формирование навыков чтения и перевода специализированной литературы для студентов энергетических специальностей, где физика является основным предметом.

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От автора

Данное учебное пособие предназначается в качестве базового курса для студентов высшей школы энергетического профиля. Пособие соответствует требованиям программы по английскому языку и рассчитано на студентов, имеющих начальную языковую программу.

Учебной целью пособия является развитие навыков чтения и понимания специальной литературы и извлечения нужной информации, что является одной из основных задач в неязыковом вузе. Основное внимание в текстах и упражнениях уделяется техническому языку, т.е. техническим и лексическим элементам, которые в некоторых случаях не могут быть переведены дословно, а в технической литературе встречаются довольно часто. Учебное пособие рассчитано способствовать развитию навыков самостоятельной работы над литературой по специальности, делать краткие сообщения и вести беседу на темы по специальности.

Пособие включает в себя четыре части и приложение. Во многих случаях тексты подверглись адаптации и сокращению. Первые три части включают тексты по изучению явлений в механике, тепловых явлений, тесно переплетающихся с явлениями молекулярной физики, и по изучению электрических и магнитных явлений. В четвертой части предложены тексты для дополнительного чтения различной тематики. При отборе материала и составлению заданий учитывалась повторяемость лексических и грамматических трудностей, типичных для технических текстов. Словарь, предлагаемый после текста, облегчает его понимание и перевод, а также способствует закреплению потенциального словаря, который является основой чтения и активного обсуждения материала. Кроме чтения и перевода текстов разной сложности предлагаются вопросно-ответные задания, которые рассчитаны на развитие и углубление навыков устной речи по специальности.

Иллюстрации и тексты подобраны из Интернет – сайтов и современных журналов.

В приложении дается глоссарий, словарь, справочник по чтению математических символов и условных обозначений.

PART 1. MECHANICS

1 Physics in our life

Everything that really exists in the world, on the Earth or out of it, is called *matter*. Various bodies surrounding us and the substances of which these bodies are composed are material. Sound, light, radiowaves are also material objects since they actually exist. This means that any object (and, in general, the material world surrounding us) exists independently of our consciousness and acts on our organs of sense.

One of the basic properties of matter is its variability. Various changes occurring in the material world, viz. changes in matter, are called natural *phenomena*.

Physic's is a science dealing with unanimate nature. It studies the properties of matter, its various changes, the laws describing these changes and the relationships between different phenomena.

The knowledge of the properties of matter and the laws of its variation (the laws of nature) is in cope with the natural tendency of a human being to know and understand the world around him. Therefore, this knowledge constitutes an important part of human culture. On the other hand, natural sciences are of utmost practical importance, since they enable us to predict the course of various phenomena and processes. And without it no enterprize can exist! For example, an engineer knows how a machine will operate even before it is constructed, since while designing it, he used information delivered by science, and above all, physics. The knowledge of the laws of nature makes it possible not only to predict the future but also to explain the past, since the laws of nature have been the same in the past and will remain unchanged forever.

The possibility to forecast the future on the basis of laws of nature has become especially important nowadays when the activity of human being, who mastered a powerful technique, strongly affects the environment. In order to avoid an irretrievable disaster due to this influence of human activity on nature, people must be able to foresee in advance the possible aftereffects. For this the deeper and deeper knowledge of the laws of nature, including those studied in physics, is required.

Mechanical motion is the best studied among all phenomena in nature. The branch of physics in which this phenomenon is investigated is called *mechanics.*

Vocabulary:

matter – вещество, материя
to exist – существовать
substance – субстанция, вещество
consciousness – сознание
to vary – изменяться
property – свойство
utmost – крайний, предельный, величайший
to constitute – составлять, основывать
animate – живой, одушевленный
to predict – предсказывать
environment – окружающая среда
to foresee – предвидеть
disaster – катастрофа, бедствие
to deal – иметь дело с
law – закон

Exercises

1. 1 Read the following international words:

material, nature, basic, organ, phenomena, variation, culture, physics, practical, machine, operate, information, construct, technique, mechanical.

1.2 Answer the following questions:

1.Why is it important to know physics?
2.What does physics deal with?
3.What is one of the basic properties of matter?
4.What does mechanics study?
5.Is it important to know the laws of nature nowadays?

1.3 Read the text about common words with special meaning in physics. Do the terms used in physics differ in their meaning from what we use in everyday life?

Some of the most important terms in physics are words which we use in a more general sense in everyday life. In physics their meaning is very specific and precise. We often use such words as energy, work, speed, force, power. When these words are used in physics, they refer to very definite things which can be measured with great accuracy and represented in standard units.

Thus, *energy* in ordinary usage means strength sufficient to do something, whereas in physics energy is defined as capacity to do work.

Again, *work* is both an everyday word and a scientific term.

In mechanics *work* is defined as the scalar product of a force multiplied by the distance through which that force acts. In other words, it means the product of force times the distance through which that force moves any object.

Similarly, *speed* as we use this word in common speech means rapid movement but in physics speed is the exact measure of the rate of motion. In other words, the term "speed" means the ratio of the distance travelled by an object to the period of time during which that distance was travelled.

2 Basic problem of mechanics

All events occur somewhere in space (where?) and at certain instant of time (when?). In particular, at any moment a body occupies a certain position relative to other bodies in space. If the position of the body in space varies with the passage of time, we say that the body moves, or is in mechanical motion.

The mechanical motion of a body is defined as the change of its position in space relative to other bodies with the passage of time.

To study the motion of a body means to determine how its position changes with time. If this is known, we can determine the position of a body at any instant of time. This is the essence of the basic problem of mechanics, i.e. the problem of finding the position of the body at any moment.

Bodies can be in quite diverse types of mechanical motion: they can move along different trajectories, faster or slower, etc. To solve the basic problem of mechanics, we must be able to describe briefly or exactly the motion of the body, i.e. indicate how its position changes with time. In other words, we must find the mathematical description of the motion, establish the connections between the quantities characterizing the mechanical motion.

Mechanical motion is of relative nature (fig. 2-1). This means that the displacement and velocity of a body in different coordinate systems moving relative to each other are different. The trajectories and path length are also different.

The state of rest is also relative. If a body is at rest relative to some reference system, there exist other reference systems relative to which it moves (fig. 2-2).

Fig. 2-1. In motion

Fig. 2-2. The state of rest is relative

Vocabulary:

to occur – случаться, происходить
instant – мгновение
certain – определенный
relative – относительный
to determine – определять
essence – сущность
diverse – отличный, различный

quantity – количество
displacement – перемещение
velocity – скорость, быстрота

Exercises

2.1 Find all the international words in the text. Mind your pronunciation.

2.2 Answer the following questions:

1. What is mechanical motion?
2. Can we determine the position of a body?
3. What is the basic problem of mechanics?
4. The mechanical motion is of relative nature. How can you explain it?

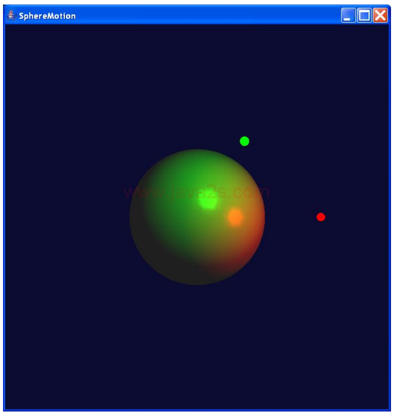
2.3 Define the part of speech of the following words and translate them:

determine, coordinate, instant, displacement, certain, relative, mechanical, briefly, length, reference, position.

2.4 State if the following sentences are true to the fact or false. Correct the false sentences.

1. A body occupies a certain position relative to other bodies in space.
2. We can’t determine the position of a body at any instant of time.
3. The basic problem of mechanics is the problem of finding the displacement and velocity of a body.
4. Mechanical motion is of constant nature.

3 Motion



Motion may be defined as a continuous change in place or position with respect to the position of some other object or objects that we assume as being at rest.

No object is really quite motionless. If houses are at rest relative to the earth's surface, the earth itself is not motionless. It revolves about its axis and around the sun; and the sun, in its turn, moves relative to the stars

Fig. 3-1. Sphere Motion which, too, are in a state of motion (fig. 3-1). We travel at a speed up to 1,800 kilometres per hour (km/hr) as the earth revolves about its axis. Our speed is a little less than 125,000 km/hr in the orbit of the earth around the sun.

Wherever movement occurs at a constant speed, it is because the forces tending to cause it are exactly balanced by other forces which tend to stop it. If the forces causing motion are greater than those opposing it, an increase in speed known as "acceleration" takes place. The reverse effect known as "deceleration" occurs if the forces opposing the motion are stronger.

The accelerating torque given by a motor depends not only upon its own characteristic curve but also upon the type of appliance that it is driving.

Speaking of movement and speed, one should mention the UNIT OF SPEED in the metre-kilogram-second (MKS) system, and in the old English system of units. The UNIT OF SPEED in the MKS system is one metre per second (m/sec). The corresponding unit in the English system of units used to be one foot per second (ft/sec).

Vocabulary:

motion – движение
to tend – иметь тенденцию, направляться
continuous – непрерывный, продолжительный
to assume – предполагать, допускать
to be at rest – находиться в покое
to move – двигаться
to revolve – вращаться
axis – ось
to cause – вызывать, быть причиной
to increase – увеличиваться
reverse – противоположный, обратный
torque – крутящий момент

curve – кривая, дуга; изгиб
deceleration – замедление; торможение

Exercises

3.1 Read the following words:

automobile, airplane, measure, specify, acceleration, torque, characteristic, appliance.

3.2 Answer the following questions:

1. What do we call "motion"?
2. Is the earth motionless?
3. Does the earth revolve around the sun?
4. Is it possible to calculate motion?
5. What is known as acceleration?
6. What does the accelerating torque depend upon?
7. What systems of units do you know?
8. What is the unit of speed in the English system of units?

3.3 Translate the following sentences, paying attention to the participle:

1. A local train and an express train are going in the same direction.
2. Revolving about its axis, the earth also revolves around the sun.
3. Having passed a short distance, the car stopped.
4. The term "speed" means the ratio of the distance travelled by an object to the period of time.
5. Speaking of the accelerating torque given by a motor, one can say that it depends upon its own characteristic curve.
6. The co-ordinate of the body is considered as negative if the body is at the left of the initial point.

3.4 Form adjectives from the following nouns using the suffix "-less" and translate them:

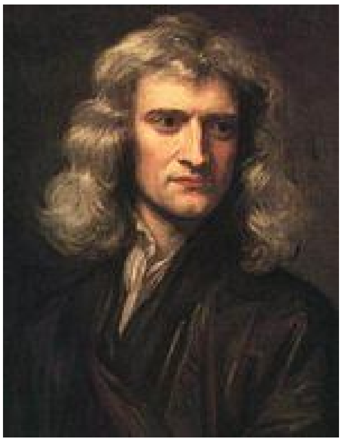
motion, use, doubt, shape, meaning, friction, power, rest.

3.5 State if the following sentences are true to the fact or false.

Correct the false sentences.

1. All objects are really quite motionless.
2. The earth is not motionless.
3. The sun revolves around the earth.
4. The co-ordinate is positive when the body is at the left of the initial point.
5. Deceleration takes place if the forces causing motion are greater than those opposing it.

4 Newton's laws of motion



Isaac Newton (1642-1727)

Isaac Newton, was born in the village of Woolsthrope in England. He was to become a professor of physics, a great scientist, a Member of Parliament and President of the Royal Society. Newton discovered universal gravitation, one of the greatest discoveries which scientific investigation ever yielded to mankind. They say that in 1665 while staying in his native village, he noticed by chance that an apple fell from a tree.

That insignificant, as it may seem, fact turned his mind to the problem of gravitation. However, to carry on scientific investigations was not so easy about three hundred years ago and it took him about twenty years to complete his theory of gravitation.

Newton was the first to realize the elliptical path of comets and was the discoverer of the three basic laws of motion which are the foundation of practical mechanics. Newton's Laws of Motion are based upon his own and Galileo's experiments. His laws of motion are to be modified when speed approaches the speed of light. However, for practical mechanical problems, the laws of motion hold good to this day.

Newton's First Law of Motion may be expressed as follows: Any object remains at rest or continues to move at constant speed in a straight line, unless it is acted upon by some force.

The rate of speeding up is commonly termed "acceleration", while the rate of slowing down is termed "deceleration". In other words, to "accelerate" is to increase speed and to "decelerate" means to slow down motion. In science, the one term acceleration is often used to designate both types of motion. The acceleration of an automobile is positive when force is supplied by the motor to speed up the car. The acceleration is negative when the retarding force of the brakes slows down the motion of the car. We even speak of acceleration when the motor-car goes round a corner at constant speed because a change in the direction of motion requires a force just as a change of speed does.

Newton's Second Law of Motion expresses the relation between force, mass and acceleration as follows: The acceleration of a body is directly proportional to the force acting and is inversely proportional to the mass of the body.

The Second Law may perhaps be expressed more simply in the form of an equation:

Force=Mass X Acceleration, or F=m X a.

This is one of the equations to be used when we want to calculate changes in speed.

Newton's Third Law of Motion may be expressed as follows: Forces always act in pairs and the two forces in a pair are equal and opposite.

To every action there is an opposite and equal reaction.

It is to be noted that the action and reaction, as the two forces of a pair are generally called, always act on different bodies and never act on the same body. Also, action and reaction are equal even when a body is accelerated. As an illustration of the Third Law, suppose that some person is pushing a door in order to open it. Do you know that the door, in its turn, will push back on his hand with an equal and opposite force?

As we know at present Newton's Third Law cannot be applied to force acting at a distance. On the other hand, it holds good for objects at rest and for contact forces. (See fig. 4-1).

Object at rest **Force** **Opposite reaction**

Fig. 4-1.

Vocabulary:

to discover – обнаруживать, открывать
mankind – человечество
to complete – завершать
to realize – осознать, понять
law – закон
to remain – оставаться, сохраняться
to supply – обеспечить, снабжать
retard – задерживать, замедлять
brake – тормоз
equation – уравнение
to calculate – вычислять
equal – равный
opposite – противоположный
to act – действовать
to push – толкать

Exercises

4.1 Read the following words:

law, quite, village, physics, scientist, parliament, society, scientific, yield, insignificant, mechanics, straight, equation.

4.2 Answer the following questions:

1. Who discovered universal gravitation?
2. What did Newton discover?
3. How many Newton's Laws do you know?
4. What is Newton's First Law of Motion?
5. What do we call acceleration?
6. What does Newton's Second Law of Motion express?

7. Do action and reaction act on the same body?

4.3 Translate the following sentences, paying attention to the infinitive:

1. Newton was the first to discover the basic laws of motion.
2. The problem to be solved requires some experiments.
3. It was not so easy for Newton to carry on scientific work at that time.
4. It took Newton about 20 years to complete his theory of gravitation.
5. It is to be remembered that Newton's Laws of Motion are the foundation of practical mechanics.
6. To slow down the car means to decelerate its motion on the road.
7. Lomonosov was the first scientist to demonstrate the molecular kinetic theory of heat and the kinetic theory of gases.
8. In physics energy is defined as the capacity to do work.
9. It is necessary to point out here that Newton's Laws are true to this day.
10. To complete this laboratory experiment will not take much time.

4.4 Give all the derivatives of the following words:

universal, mechanics, physics, scientist, express, practical, equal, discover, calculation, reaction, operation, consider, foundation, experiment.

5 The importance of Newton’s Laws

The laws of motion expressed by two formulas contain rich information. Different kinds of motion occur around us; water flows in rivers, waterfalls come down, wind and hurricanes blow over the Earth, motorcars run on the roads, ship sails in the seas, airplanes fly in the air, galaxies, stars, planets and artificial satellites are in motion in space. These motions as well as bodies are different. The forces acting on the bodies are also different. However, Newton’s laws are equally valid for all these motions, bodies and forces. These laws are expressed analytically in the formulas which seem to be very simple.

Newton’s mechanics was the first complete theory in the history of physics which correctly described a large class of phenomena, viz. the motion of bodies.

Newton's laws permit, in principle, to solve any problem in mechanics. If the forces applied to a body are known, its acceleration can be found at any point of the trajectory at any instant of time.

Thus, from known forces and mass of the body, its acceleration is determined. Then the velocity of the body and its displacement over any interval of time are calculated. Finally, the coordinates of the body at any instant of time are found. For this we must know the "initial conditions", viz, the initial position and initial velocity of the body.

Vocabulary:

to contain – содержать
waterfall – водопад
hurricane – ураган
force – сила
valid – основательный, имеющий силу
to permit – разрешать, позволять
to solve – решать
artificial – искусственный
acceleration – ускорение
to calculate – вычислять
initial – первоначальный
displacement – перемещение

Exercises

5.1 Read the following international words. Mind your pronunciation:

formula, information, satellite, analytically, theory, physics, acceleration, trajectory, mechanics, coordinate, calculate, finally, interval.

5.2 Answer the following questions:

1. Do we have different kinds of motion?

2. Why are Newton's laws equally valid for all the motions?
3. What problems do Newton's laws permit to solve in mechanics?
4. How can the acceleration of a body be found?
5. What should we know in order to define the coordinates of the body at any instant of time?

5.3 Read the words of the same root and translate them into Russian:

- to differ, different, difference, indifferent, indifference;
- to act, action, interaction, active, reaction;
- to accelerate, acceleration, deceleration;
- to place, placement, displacement, replace;
- to calculate, calculation, calculator.

5.4 Translate the following sentences. Pay attention to the infinitive constructions:

1. All bodies are known to possess weight.
2. Newton noticed the apple fall from thee tree.
3. The acceleration is said to be positive when the force is supplied by the motor to speed up the car.
4. They saw the strange creature climb up the tree.
5. The invention of this device is expected to produce a great increase in the production of the material.
6. At present we know heat to be a form of energy.

5.5 Give all the derivatives of the following words:

universal, mechanics, scientist, practical, equal, describe, contain.

6 Pressure and force

Commonly, the terms pressure and force are used interchangeably. In everyday life we often hear the word "pressure" used, and generally its meaning is not considered to be very different from that of the word "force". The two words are closely related, of course, however there is an important difference in their meaning.

Force may be defined as any action that causes the change of the rate or direction of speed of bodies as, for example, the cause of accelerating a freely falling body.

In mechanics the word "pressure" has a more limited and exact meaning than the word "force", namely, pressure is defined as the force per unit area.

Pressure acts equally in all directions. It always acts at right angles to whatever surface it is pushing against, any increase in pressure in a vessel being transmitted equally to all surfaces. Saying "in a vessel", we realize that in physics pressure is most commonly associated with gases and liquids as well as with the forces they exert on bodies immersed in them.

Pressure in any fluid is due to one of two causes: either compression by some sort of mechanical pumping device or the weight of the fluid itself. Thus, automobile tires are inflated with air compressed by a pump to be operated either by hand or by motor. The pressure on the sea bottom is due entirely to the weight of water above plus atmospheric pressure.

Studying the equilibrium of a small submerged particle of a liquid at rest, we find that the only forces acting on it are: 1 — its weight, and 2 — static thrusts.

A liquid in motion presents an entirely different condition. Although the motion of water or any other liquid undoubtedly takes place in accordance with definite laws, these laws and the influence of surrounding conditions upon them are very complex.

Vocabulary:

to consider – рассматривать, считать
direction – направление
angle – угол
surface – поверхность
vessel – сосуд;
liquid – жидкость
to exert – оказывать давление; влиять

to immerse – погружать
fluid – жидкость
due – должный, обязанный, соответствующий
pump – насос
device – устройство
weight – вес
tire – шина
to inflate – надувать, наполнять
bottom – дно
entirely – полностью
to submerge – затоплять; погружать(ся)
thrust – толчок, удар; тех. опора, упор
condition – условие
in accordance with – в соответствии с

Exercises

6.1 Read the following words:

pressure, interchangeably, cause, mechanics, liquid, submerge, thrust, calculate, depth, weight, entirely, atmospheric, pressure, height, square.

6.2 Answer the following questions:

1. What do we call force?
2. How is the word "pressure" defined in mechanics?
3. Does pressure act only in one direction?
4. What is the cause of pressure?
5. Is pressure associated with gases only?
6. What forces act on a small submerged particle?
7. Is it possible to calculate pressure?

6.3 Translate the following sentences:

a) 1. Lomonosov was the first to study the kinetic theory of gases.
2. The useful work to be done by a machine is less than the total work to be performed by it.

3. The volume to be contained in this column of water is 6 cubic metres.
4. The instrument to be used for testing purposes is similar to that used in our laboratory.
5. The phenomena to be studied are of special significance.
6. The forces to act on a small submerged particle are given below.

b) 1. The phenomenon discovered attracted the scientists' attention.
2. The article translated belonged to our professor.
3. The methods applied increased the production of motor-cars.
4. The weight of the liquid used can be easily calculated.
5. The properties described required further investigation.

c) 1. The principle the scientists employed in their experiments is quite new and original.
2. The students were given a problem they had to solve.
3. The facts you have been given above illustrated the use of instruments on a large scale.
4. The phenomena you are talking about were discovered by famous scientists.
5. The inventor demonstrated the machine he had worked at.
6. The theory you are interested in was first developed in this country.

6.4 Translate the following adjectivised nouns used as attributes:

liquid fuel, liquid fuel container, liquid fuel container design; steam power, steam power plant, steam power plant equipment, steam power plant equipment program; boiler room, power station boiler room, power station boiler room construction; solid state, solid state physics, solid state research worker; temperature coefficient, negative temperature coefficient, negative temperature coefficient study.

6.5 Find synonyms among the following words and arrange them in pairs:

automobile, due to, different, power, motor-car, vessel, liquid, container, speed, fluid, for instance, rate, owing to, various, energy, for example.

7 Forces in nature

At first sight, there is a large number of force types the bodies act on each other, and hence, there are many types of interactions. We can impart an acceleration to a body by pushing or pulling it by the hand. Any body falling to the Earth moves with an acceleration. A ship whose sails are

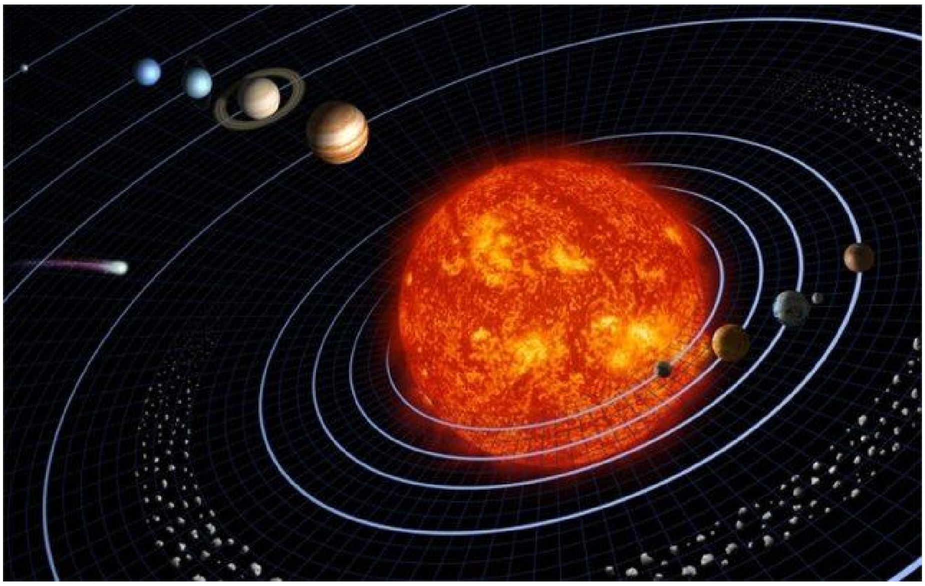


Fig. 7-1. The gravitational force keeps the planets in orbit

blown up by the wind starts moving with an acceleration. Stretching and releasing the bow string, we impart an acceleration to the arrow. In all these cases some forces are acting, which seem to be quite different. Naturally, we can mention many other forces also. Everybody knows about electric and magnetic forces, forces of earthquakes, tides, etc.

While considering mechanical motion of bodies, we have to deal only with three types of forces: *elastic force, force of friction and gravitational force (7-1).*

However, these three types of forces are the manifestation of only two main forces in nature, which are indeed of different origin. These are *electromagnetic forces* and *gravitational forces.*

Let us first consider electromagnetic forces. It is known that there is a force which is acting between electrified bodies and called electric force.

Electric forces can be either attractive or repulsive. Charges of two types exist in nature. They are conventionally called positive and negative charges. Two with like charges repel and with unlike charges attract each other.

Electric charges possess a very interesting property. When they are moving relative to each other, one more force is acting between them in addition to an electric force. This is a magnetic force.

These two forces – electric and magnetic – are related to each other so closely that they cannot be separated: they acting *simultaneously*. Since we deal as a rule with moving charges, the forces acting among them can be called neither electric nor magnetic. They are called electromagnetic forces.

Electromagnetic interaction is responsible for elastic forces and friction.

Elastic force is the force appearing during deformation of a body and having the direction opposite to the displacement of particles of the body (see fig. 7-2).

Elastic force and gravitational force depend on the mutual arrangement of interacting bodies, i.e. on the coordinates.

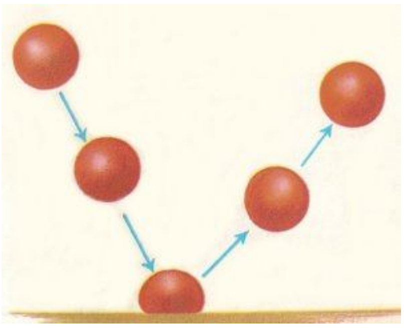


Fig. 7-2. A rubber ball is badly deformed upon impact with the ground but always regains its original form

Friction emerges when bodies in contact are either at rest (static friction) or in motion (sliding friction). Friction is directed along the contact surface against the direction of the relative motion of the bodies in contact (see fig. 7-3). Friction depends not on the coordinate of one body relative to the other but on their relative velocity.

The force of *universal gravitation* is a manifestation of gravitational interaction, viz. the force of attraction to the Earth. All bodies attract one another with a force whose magnitude is directly proportional to the product of their masses and inversely proportional to their squared separation.

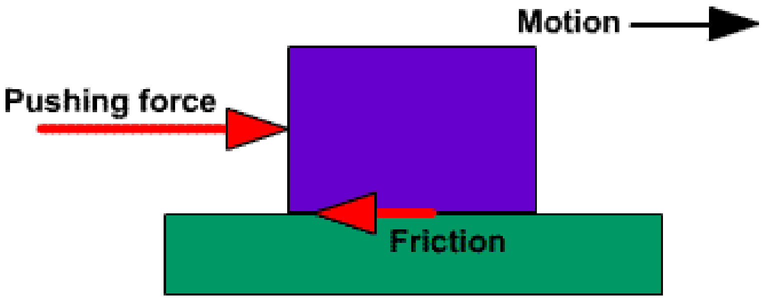


Fig. 7-3. Pushing force is greater than friction force

Vocabulary:

interaction – взаимодействие
impart – давать, передавать, сообщать
to stretch – натягивать
bow - лук
arrow – стрела
earthquake – землетрясение
tide - прилив
elastic – эластичный, упругий, гибкий
friction – трение
mutual – взаимный
to attract – притягивать
magnitude – величина
inversely – обратно
surface – поверхность
to emerge – возникать

Exercises

7.1 Read the following international words:

interaction, acceleration, naturally, magnetic, contact, elastic, gravitational, manifestation, nature, origin, electromagnetic, deformation, proportional, separation, coordinate.

7.2 Answer the following questions:

1. Does any body falling to the Earth move with acceleration?
2. What types of force do we deal with while considering mechanical motion of bodies?
3. What are two main forces in nature? What origin are they?
4. Can we consider electric and magnetic forces separately?
5. What is elastic force?
6. What is universal gravitation?
7. When does friction emerge?

7.3 Find antonyms among the following words and arrange them in pairs:

repel, acceleration, like, attract, positive, unlike, rest, negative, attractive, motion, repulsive, deceleration.

7.4 Complete the sentences with words given below:
body, exist, possess, coordinate, deformation, interaction, forces.

1. Any__________ falling to the Earth moves with an acceleration.
2. Electric _________ can be either attractive or repulsive.
3. Charges of two types__________ in nature.
4. Electric charges __________ a very interesting property.
5. The force of universal gravitation is a manifestation of gravitational __________ .
6. Friction depends not on the __________ of one body relative to the other but on their relative velocity.
7. Elastic force is the force appearing during ____________of a body and having the direction opposite to the displacement of particles of the body.

8 The meaning of the words “work”, “energy” and “power”

Many words that we use in our everyday speech assume a more precise and often restricted meaning in the language of science. The words "work", "energy", and "power" are quite familiar to everyone, nevertheless, their use in scientific terminology presents certain difficulties.

The word "work" may serve as an example. Besides its being an English word in common usage, it is also a scientific term which has a special meaning when used in mechanics. The scientific term "work" is much more restricted. Mechanical work is performed only when a force moves some object through a distance.

One can perform work by lifting a box from the floor. Pushing the box along the floor against friction also means doing work. According to physical laws you cannot perform any work, scientifically speaking, by pushing an automobile which is standing on the road, unless it starts moving. Thus, in order to do mechanical work two conditions are necessary, namely, there must be a force and it must act through a distance. Generally speaking, the greater the force and the distance moved, the greater the work performed.

Work and energy are very closely related. Indeed, one may say that the energy of a body or system is the capacity of that system or body for doing work. Power is related to both work and energy. It is the rate of performing the work in a unit of time.

While energy is the capacity for work, power is the quantity of work done in a unit of time. When a kilogram is lifted to a height of one metre, we say that a kilogram-metre of work is accomplished. The amount of the accomplished work does not depend on the time spent on lifting this weight.

Measuring power, we generally use such units as watts, kilowatts, and kilogram-metres per second. Seventy five kg. m. s. (kilogram-metres per second) or 736 W (watts) form a horse-power. A horse-power is a unit for measuring the amount of work performed per second.

Discussing the term "energy", we shall follow the transformation of one form of energy into another.

Vocabulary:

to restrict – ограничивать
familiar – знакомый
certain – определенный
to serve – служить
common – общий; общественный; простой
to perform – выполнять, осуществлять
to lift – поднимать
to push – толкать
condition – условие
necessary – необходимый
to relate – устанавливать связь; иметь отношение
quantity – количество
to accomplish – выполнять, осуществлять
average – средний
to measure – измерять
amount – количество

Exercises

8.1 Read the following words:

scientific, precise, usage, nevertheless, quantity, height, amount, weight, average, measure.

8.2 Answer the following questions:

1. What terms are discussed in this text?
2. When is mechanical work performed?
3. What conditions are necessary in order to do mechanical work?
4. Are work and energy closely related?
5. What do we call power?
6. What is necessary for considering power?

7. What units are used for measuring power?

8.3 Translate the following sentences and define the functions of the gerund:

1. Work can be performed by lifting a weight.
2. Watts, kilowatts and kilogram-metres per second are used for measuring power.
3. We know of work and energy being closely related.
4. Pushing an object along the floor means performing work.
5. Could you understand this article without consulting a dictionary?
6. In physics energy is defined as capacity for doing work.
7. Lifting this heavy weight is impossible without using necessary appliances.
8. The automobile was standing without moving along the road in spite of our pushing it so hard.

8.4 State if the following sentences are true to the fact or false. Correct the false sentences.

1. To do mechanical work there must be a force.
2. The greater the force and the distance moved, the greater the work that has been performed.
3. Power is related to both work and energy.
4. For measuring work we use such units as watts and kilowatts.
5. The word "work" is a scientific term which is never used in our everyday life

9 Energy and its forms

Scientifically speaking, energy is the capacity for doing work. When a body is capable of performing work, it possesses energy. It is quite clear that the more work a body can do, the more energy it possesses.

There are numerous forms of energy, such as: electrical, chemical, mechanical, heat energy and so on. In mechanics, we are interested in two special kinds of energy, namely, kinetic energy and potential energy.

It is quite possible to transform one form of energy into another. Take a waterfall as an example: when water falls from a height, the energy is said to change from potential to kinetic. If there is a hydroelectric plant at the waterfall, the energy of the falling water is used to drive the turbines. The turbines are driven by the kinetic energy of the water. Since it is difficult to transfer mechanical energy over a great distance, it is used here to drive generators. These generators, in their turn, change mechanical energy into electric energy.

Forms of Energy. There are many forms of energy, but they can all be put into two categories: kinetic and potential. Kinetic energy is the energy of motion, while potential energy is that of position. The kinetic energy of an object is the energy that it possesses because of its speed. Any moving object is expected to perform work simply because it is moving, the quantity of energy depending on its mass and velocity. It has been found that the greater the mass and the velocity, the greater is the kinetic energy.

Kinetic energy is motion–of waves, electrons, atoms, molecules, substances, and objects (fig. 9-1).

Fig. 9-1. Kinetic energy

Electrical Energy is the movement of electrical charges. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrical charges moving through a wire is called electricity. Lightning is another example of electrical energy.

Radiant Energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.

Thermal Energy, or heat, is the internal energy in substances—the vibration and movement of the atoms and molecules within substances. Geothermal energy is an example of thermal energy.

Motion Energy is the movement of objects and substances from one place to another. Objects and substances move when a force is applied according to Newton’s Laws of Motion. Wind is an example of motion energy.

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate — the energy is transferred through the substance in a wave.

Potential energy is stored energy and the energy of position — gravitational energy. There are several forms of potential energy.

There are five potential sources: hydrothermal, reservoirs, earth energy, geopressured brines, hot dry rock and magma.

Chemical energy is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.

Stored Mechanical Energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Nuclear Energy is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called fission. The sun combines the nuclei of hydrogen atoms in a process called fusion. Scientists are working on creating fusion energy on earth, so that someday there might be fusion power plants.

Gravitational Energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

Energy

Vocabulary:

to possess – обладать, иметь
numerous – многочисленный
waterfall – водопад
plant – завод
turbine – турбина
generator – генератор
velocity – скорость; быстрота
charge – заряд
to apply – применять, использовать
lightning – молния, грозовой разряд
ray – луч
wave – волна
radiant – излучающий свет, лучистый

thermal – тепловой, термальный
substance – вещество
to store – хранить, накапливать
to combine – комбинировать, сочетать
to split – расщеплять, расколоть
fission – расщепление, разделение
to release – освобождать, отпускать
to contain – содержать

Exercises

9.1 Read the following words:

scientifically, weight, mechanism, height, hour, chemical, light, hydroelectric, quantity, electron, atom, molecule, substance, nuclei, thermal, earth.

9.2. Answer the following questions:

1. What do we call energy?
2. When does a body possess energy?
3. What forms of energy do you know?
4. What do we call kinetic energy?
5. What do we call potential energy?
6. Can one form of energy be transformed into another?

9.3 Translate the following sentences:

1. Кинетическая энергия – это энергия движения.
1. Хорошо известно, что существуют различные формы энергии.
2. Один вид энергии может преобразоваться в другой вид энергии.
3. Энергия падающей воды используется для приведения в действие турбины.
4. Совершенно ясно, что количество энергии зависит от массы и скорости движущегося тела.
5. Трудно передавать механическую энергию на большие расстояния.

9.4 Translate the following sentences, paying attention to the passive voice:

1. Newton's Laws of Motion are often referred to.
2. The students are taught to make experiments.
3. Different forms of energy are dealt with in the present article.
4. Extensive research work is carried on at our university.
5. Voltmeters are often made use of in our laboratory.
6. He was asked to show the results of his experiment.
7. Devices that are operated by electrical energy help us in our work.

9.5 Translate into Russian in writing:

Energy is the capacity for doing work. The various forms of energy, interconvertible by suitable means, include potential, kinetic, electrical, heat, chemical, nuclear and radiant energy. Interconversion between these two forms of energy occurs only in the presence of matter. In the absence of matter energy can only exist in the form of radiant energy.

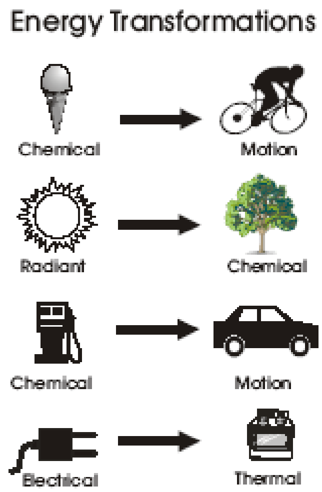
9.6 Form as many new words as possible from the words given below:

chemical, mechanics, compress, useful, produce, possible, use.

10 Law of conservation and transformation of energy

If a given amount of energy is put into a machine, precisely that very amount will be developed, neither more nor less. This law is universally known and all physical phenomena follow it.

We know a number of cases where one kind of energy is transformed into another. Whenever energy in one form is expended, an equal amount of energy in some other form takes its place.



We have different units in which various forms of energy are measured but after the conversion of work into heat, or chemical energy into work or into electrical energy, the actual amount of energy is the same as before the change. In other words, when energy is spent, there is still as much energy as before. This fact which is one of the fundamentals of physics is known as the Law of the Conservation and

Transformation of Energy (fig. 10-1).

According to this law energy can neither be created, nor destroyed although its form can be changed. All the transformations, the endless number of chemical changes that are always taking place, are only changing energy from one form into another without affecting the total. Though it is quite true that energy cannot disappear, it is an unpleasant fact that it very easily turns into a useless form.

Fig. 10-1. Energy transformations

All machines and appliances have some energy "loss", that energy being converted into useless heat due to friction. Hence, the useful work to be done by a machine is less than the total work performed by it. The energy lost for work is not really lost but only converted into another form. No machine can be made completely frictionless but the undesirable effects of friction can be reduced, of course. Friction reducing the efficiency of our machines, one might think that it is always undesirable. However, it would be a misconception of that phenomenon, since but for friction it would be impossible to control the motion of any machine.

We have already noted that we always lose some useful energy when machines are used. Why then do we use them in spite of that disadvantage? We often use machines to transfer energy from one place to another and to transform energy. The dynamo, for example, changes mechanical energy into electric energy. The energy of water is also transformed into electric energy by means of hydraulic turbines.

Wherever there is motion, we see the process of conversion of mechanical energy into heat. Is it possible to reconvert heat into mechanical energy? Yes, undoubtedly, it is (fig. 10-2). Besides, just as mechanical energy and heat can be interconverted, so can heat and chemical energy be converted one into another.

Fig. 10-2. Modern wind turbines convert the kinetic energy of wind into mechanical energy, which is used to generate electricity or to pump water for irrigation.

Vocabulary:

amount – количество
to expend – тратить, расходовать
actual – действительный, подлинный
to convert – превращать, преобразовывать
according – согласно, в соответствии
to create – создавать, творить
to destroy – разрушать
total – целый, общий
to affect – воздействовать
to turn – превращать
appliance – устройство, прибор
heat – тепло
due – должный, соответствующий; обусловленный
hence – отсюда; следовательно
to lose (lost, lost) – терять
to reduce – сокращать
efficiency – эффективность
by means – при помощи, посредством

Exercises

10.1 Read the following words:

precisely, neither, universally, physical, phenomena, whenever, law, though, machine.

10.2 Answer the following questions:

1. What laws are discussed in this text?
2. Can energy be created and destroyed?

3. Is energy easily turned into a useless form?
4. Why is energy converted into useless heat?
5. What reduces the efficiency of machines?
6. Is friction always undesirable?
7. What machine changes mechanical energy into electric energy?
8. By what means is the energy of water transformed into electric energy?
9. When is mechanical energy converted into heat?
10. Can chemical energy be converted into heat?

10.3 Translate the following sentences, paying attention to the words in bold type:

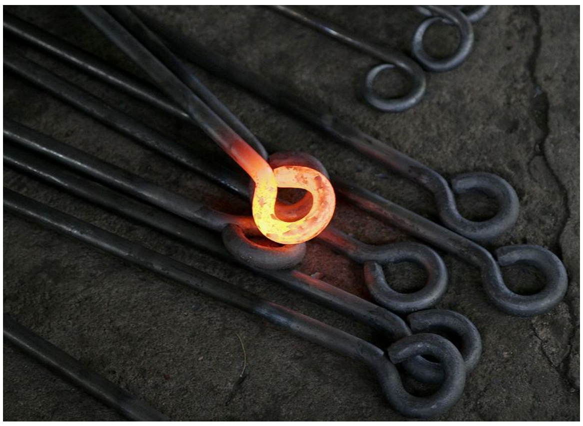
1. Steel is used **for** making different parts of machines.
2. **For** 2 thousand years it was believed that all heavy objects fell faster than light ones **for** Aristotle had stated that it was so.
3. The engineer saw that all the devices **but** one were operating in the proper way.
4. There is **but** one way for solving the problem **but** it will take too much time.
5. The metric system is adopted by all the countries of the world **but** England and America.

10.4Form new words, using prefixes and suffixes:

transform, equal, vary, end, appear, possible, pleasant, use, real, convert, friction, desire, history, advantage, conception.

PART 2. MOLECULAR PHYSICS

11 Heat is a form of energy



When heat, a form of energy, is supplied to a substance, we expect it to produce a rise of temperature. In other words, heat usually causes an increase in the average kinetic energy of the random motion of the molecules of which the substance is made up. However, heat may also produce a change of state without any temperature change.

Today heat is known to be a form (fig. 11-1).

Fig.11-1. Hot metal

The great scientist Lomonosov was among the first to find and state that heat phenomena were due to the motion of molecules. That statement of his resulted from many carefully performed laboratory experiments, from study and observation.

Lomonosov's theory laid the foundation for the present-day molecular-kinetic theory of heat. His statement was finally proved long after his death. The caloric theory of heat is known to have existed almost up to the middle of the 19th century.

The unit of heat is called a therm or a calorie; the latter term appears to come from the Latin word "calor" which means heat.

A calorie is defined as the amount of heat required at a pressure of one atmosphere, to raise the temperature of one gram of water one degree Centigrade. (We know the gram to be a metric weight equal to 15.432 grams of the English system of weights).

One should not think that the very amount of heat which will raise the temperature of one gram of water from 0 to 1° C will also raise the temperature of the same mass of water from, say, 60 to 61° C. Experiments have shown that the quantities of heat to be required in these two cases are slightly different. Hence, the true calorie is defined as that quantity of heat which will raise the temperature of 1 gr of water from 19.5 to 20.5° C.

Vocabulary:

heat – тепло, теплый
to produce – производить, создать
to supply – снабжать, обеспечивать
rise – подъем, повышение
to cause – вызывать, быть причиной
average – средний

random – наугад; беспорядочный
to state – утверждать, заявлять
motio – движение
foundation – основание
to prove – доказывать
to exist – существовать
to appear – появляться
quantity – количество
to require – требовать
true – верный, правильный

Exercises

11.1 Read the following words:

kinetic, molecule, eventually, pound, iron, mechanical , inability, substance, finally, phenomenon, century, theory, experiment.

11.2 Answer the following questions:

1. What is heat?
2. What does heat usually cause?
3. What is a substance made up of?
4. Does heat always produce a change of temperature?
5. Who was among the first to state that heat phenomena were due to the motion of molecules?
6. What is the unit of heat?

11.3 Complete the blanks. Use a dictionary to check any spelling which you are not certain about.

A) Verbs	**B) nouns**
For example:	
transform	transformation
1. produce	___________
2. ___________	observation
3. exist	__________

4. ___________ foundation
5. define _________
6.____________ action
7. reduce __________
8. ___________ application
9. install _________
10. ___________ acceleration

11.4 Translate the following sentences, paying attention to the infinitive:

1. To prove any statement is a very difficult task.
2. At present every engineer can explain the production of heat due to friction.
3. To supply heat to a substance means to raise the temperature or to change the state of this substance.
4. The caloric is known to be the unit of heat.
5. An object is said to be hot if its temperature is higher than that of our body.
6. To heat a body, heat must be supplied to it.
7. The amount of heat energy to be supplied to a substance depends on the property of that substance.

11.5 Find antonyms among the following words and arrange them in pairs:

create, disadvantage, heat, expand, to receive, cold, destroy, motion, solid, increase, cool, hot, rest, liquid, decrease, high, contract, to transmit, low, advantage.

12 Heat and temperature

At present, we know heat to be a form of energy and to be capable of performing work. Heat may be converted into mechanical energy and heat, in its turn, is generated when mechanical motion is destroyed by friction.

An object is said to be hot if its temperature is higher than that of our bodies, or cold if its temperature is much lower. If a hot body is brought into contact with a cold one, the hot body will cool and the cold body will become warmer. We explain it by the fact that the hot body has transferred some amount of heat to the cold one. If two bodies *A* and *B* are brought into contact and heat is transferred from *A* to *B*, we say that *A* is at a higher temperature than *B*, or that *A* is hotter than *B*.

To measure temperature it is necessary to choose some kind of temperature scale. This may be done by means of some substance which changes with temperature changes. For example, a liquid such as mercury is known to expand when it is heated. Therefore, its change of volume due to heating is often used to measure the change of temperature.

Vocabulary:

capable – способный; умелый
hot – жаркий, горячий
low – низкий
cool – прохладный
to transfer – передавать
to choose (chose, chosen) – выбирать
scale – шкала
mercury – ртуть
therefore – следовательно
volume – объем

Exercises

12.1 Read the following words:

amount, accurate, convert, volume, liquid, mercury, temperature, thermometer, sensation, mechanical, motion.

12.2 Answer the following questions:

1. What is heat?
2. Is heat capable of performing work?
3. Is heat a form of motion?
4. Does mercury expand when heated?
5. What instrument is used for measuring temperature?

12.3 Translate into English the following word - combinations:

измерять температуру, форма энергии, передавать тепло, превращаться в механическую энергию, выполнять при помощи, расширяться при нагревании, переходить от более горячего тела к более холодному.

12.4 Translate the following sentences, paying attention to the words in bold type:

1. Do you know the **meaning** of the term "caloric"?
2. The thermometer which you **mean** is not the only **means** of measuring temperature.
3. A thermometer is an instrument **by means** of which temperature is measured.
4. What does the word "therm" **mean**?
5. It is necessary to find the **mean** temperature of the body under consideration.
6. What do you **mean**?

12.5 Form nouns from the following verbs and translate them:

to produce, to consider, to explain, to suppose, to propose, to demonstrate, to move, to observe, to found.

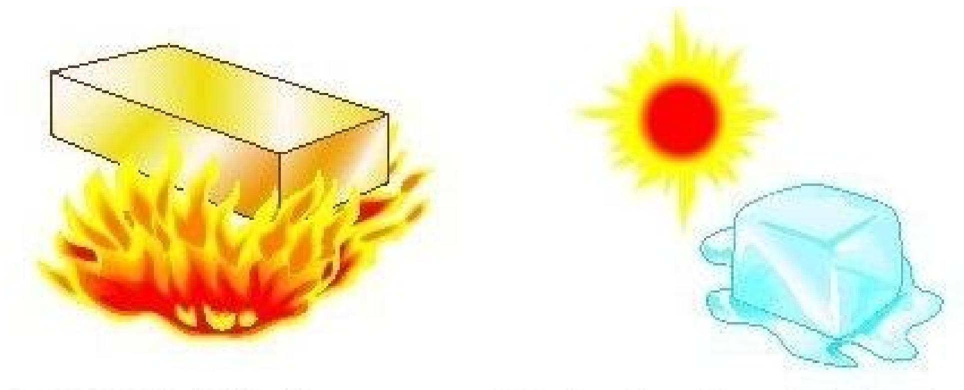
13 Internal energy

A thermometer tells you the temperature of a substance but not the amount of internal energy in it. We know a cup of water at boiling point to be hotter than the water in a lake, however, the lake contains much more energy than the cup does. A large piece of ice will melt if thrown into the lake but only a small piece of ice could be melted by the hot water in the cup. The lake can give up more energy than the cup of water, even though the lake is at a much lower temperature. Thus, to measure the amount of energy given to an object, one must do more than simply determine its temperature change.

Here is another example to be considered. Let us take a small cup of boiling water and a large container also full of boiling water.

Both of them, certainly, have the same temperature. Thermometers would show the same reading for both the water in the cup and that in the container. They do not, however, contain the same amount of energy. It takes much more heat to make the water boil in the large container than it is required to boil the small cup of water. We see that the temperature of an object does not indicate the amount of energy to be contained in that object (fig. 13-1).

The amount of energy in a given body appears to depend on the nature of the body as well as on its size and temperature. Two bodies of equal weight but of dissimilar materials may have the same temperature but contain quite different amounts of energy. A 100-gram ball of iron at a given temperature is known to contain a smaller quantity of energy than does a 100-gram aluminium ball at the same temperature. «But what does the expression the same temperature really mean?» one might ask. Two bodies are assumed to have the same temperature if, when one of these bodies is placed in contact with the other one, neither will transfer heat to the other.



a) **b)**

Fig. 13-1.

a) A metal block heated in a flame gains energy from the flame and its temperature increases. The energy transferred to the metal block is stored as internal energy.

b) An ice cube melting under the Sun gains energy from the surroundings. The energy transferred to the ice cube is also stored as internal energy.

A heated metal ball to be placed in contact with a piece of ice will transmit its heat to the piece of ice, that heat melting the ice. The fact that the metal ball loses heat shows that the two materials are not at the same temperature.

In any process, where heat is transferred, the body which is at a lower temperature is the one that gains heat.

To know the quantity of energy present in a body is very important, therefore, one should know what units are to be used for measuring the quantity of heat and how to find the amount of energy the body possesses.

Vocabulary:

internal – внутренний
to boil – кипеть
point – точка кипения, пункт
however – однако, тем не менее
to contain – содержать
piece – часть, кусок
to melt – таять, плавиться
to throw (threw, thrown) – бросать
thus – таким образом
to determine – определять
to consider – рассматривать, считать
same – тот же самый
both – оба, обе
to indicate – означать
to appear – появляться
to weigh – весить
similar – похожий, подобный
iron – железо
to gain – получать; достигать

Exercises

13.1 Read the following words:

internal, measure, however, require, size, weight, ice, furnace, amount, sufficient, thermometer.

13.2 Answer the following questions:

1. What does a thermometer tell us?
2. Does a thermometer tell you the amount of internal energy in a substance?
3. Why can the lake give up more energy than a cup of boiling water?
4. What does the amount of energy in a given body depend on?
5. What will happen to a piece of ice if it is placed in contact with a heated metal ball?
6. Does the temperature of an object indicate the amount of energy contained in it?
7. Is heat transferred from a cold body to a hotter one?
8. What does the expression "the same temperature" mean?

13.3 Give Russian equivalents to the following word – combinations:

boiling point, amount of internal energy, determine the temperature change, boiling water, to contain the same amount of energy, to transfer heat to the other body, a heated metal, for measuring the quantity of heat, to lose heat.

13.4 Translate the following sentences, paying attention to the infinitive constructions:

1. The amount of energy in a given body is known to depend on the nature of the body.
2. We expect most bodies to expand when heated.
3. We know heat to pass from a hotter body to a colder one.
4. The internal energy appears to be associated with the configurations of the particles of which the atom is composed.
5. If you want to make the water boil you must raise the water temperature to 100° C.
6. An object seems to be cold if its temperature is much lower than that of our body.
7. Under certain conditions heat is expected to produce a change of

state without any change of temperature.

13.5 Translate the following sentences, paying attention to the words in bold type:

1. If the water is heated in a closed container, the temperature and the pressure **both** rise.
2. Both Lomonosov and his friend Rihman worked at atmospheric electricity. **Both** of them made experiments on that subject.
3. Take **both** a small cup of boiling water and a large container also full of boiling water; you will find that **both** of them have the same temperature.
4. Gases have **neither** size **nor** shape.
5. **Neither** of the two experiments was carried on successfully.
6. Heat was considered to be a weightless substance which was **neither** created **nor** destroyed.
7. **Neither** of two observed substances could be heated to a high temperature.

14 Heat, temperature and molecular energy

The law explaining gas pressure on the wall of a container as a result of the collision of separate molecules was first discovered and formulated by Daniel Bernouilli, a member of the Petersburg Academy of Sciences, in 1738. He obtained a result of great significance and the "Bernouilli effect" is still considered as one of the basic laws of thermodynamics.

In 1744 Lomonosov stated the principles of the kinetic theory of gases and explained many phenomena from the molecular-kinetic point of view. It was not until the middle of the 19th century that the molecular-kinetic theory of gases found its further development.

According to the molecular-kinetic theory, the molecules always collide with one another and change direction, the speed of the molecular motion greatly depending on the temperature. At an average room temperature, a gas molecule travels at the tremendous rate of several hundred metres per second, making more than five milliard collisions with other speeding molecules (or against the walls of the container) every second. The total energy of the gas is simply the energies of all separate molecules taken together.

In mechanics we call the energy of motion — kinetic energy. We say, accordingly, that the temperature of an object depends on the average kinetic energy of its molecules travelling in various directions. When an object is heated the average speed of its molecules is increased, their average kinetic energy becomes greater, that is, the object is at a higher temperature. In other words, the temperature being raised, the kinetic energy is increased; the molecules move faster, and greater pressure is created by the bombardment against the walls of the container. As a gas or any other body is cooling down, the average speed of its molecules decreases.

Different molecules have different speeds, the average speed of all molecules remaining the same as long as the temperature is constant. Two objects being at the same temperature, the average energy of motion of their molecules is the same. Generally speaking, the amount of energy in an object also depends on the number of molecules, each of which has a certain average kinetic energy.

In the above-mentioned case of the large container and the small cup of boiling water, as the water temperature is the same in both the cup and the container, the average speed of the molecules is also the same. However, the large container having more molecules of water than the small cup, the total kinetic energy of all its molecules is many times greater. If it contains 15 cups of water, it will have 15 times as much energy because there will be 15 times as many molecules in it as in one cup.

Vocabulary:

to collide – сталкиваться
separate – отдельный
to obtain – получать, достигать
significance – значение
basic – основной, базовый

point of view – точка зрения
average – средний
tremendous – огромный, значительный
total – целый, общий
to increase – увеличиваться
to decrease – уменьшаться
to raise – поднимать
fast – быстрый

Exercises

14.1 Read the following international words:

temperature, molecular, thermodynamics, mechanics, kinetic, molecule, result, formulate, gas, theory, proportional.

14.2 Answer the following questions:

1. What law did Bernouilli discover?
2. What principles did Lomonosov state?
3. Does the speed of the molecular motion depend on the temperature?
4. Do the molecules collide with one another?
5. What do you call kinetic energy?
6. What does the temperature of an object depend upon?
7. When is the average speed of molecules increased?
8. When does it decrease?
9. What does the amount of energy in an object depend on?

14.3 Translate the following sentences, paying attention to the participle:

1. The atoms form combinations known as molecules, a molecule being defined as the smallest part of a substance.
2. A heated metal ball placed in contact with a piece of ice transmits its heat to the piece of ice, that heat melting the ice.
3. What is the temperature of boiling water?
4. Having made many tests, the engineer obtained a result of great significance.
5. The law formulated by this scientist is very important in thermodynamics.

6. The principles of the kinetic theory of gases stated by Lomonosov in 1744, are true to this day.
7. For a given body, the temperature is proportional to the amount of energy that this body contains.
8. A gas cooling down, the average speed of its molecules decreases.

14.4 Find synonyms among the following words:

to obtain, to design, to turn on, speed, different, average, main, motion, vessel, mean, movement, to construct, to get, rate, principle, container, to switch on, various.

14.5 Translate the following words having the same root:

to depend, dependence, dependent, independent; to mean, meaning, meaningful, meaningless; divide, division, divisible, indivisible.

15 Atoms and molecules

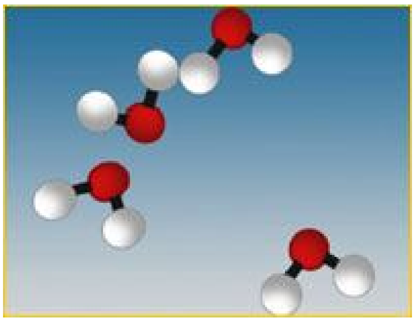


Fig. 15-1. Atoms

About the fifth century Democritus, a Greek philosopher, stated that all matter is made up of particles called atoms (fig.15-1) and that the space between atoms is completely empty (a vacuum). It is interesting to mention here that the Greek word "atom" means indivisible.

Originally the atom was believed to be a minute but solid mass. However, many years ago it was shown that the atom is more like a small solar system, with extremely small bodies revolving around its central nucleus. These minute bodies behave much as the planets in the solar system for they travel in definite orbits and the whole system is held together by forces of attraction to the central nucleus. It was also found that these small planets carry extremely small charges of negative electricity and they were named electrons.

We know that there are about 104 different kinds of atoms that exist naturally on the earth. Substances made up entirely of one kind of atom are known to be chemical elements. Hydrogen, carbon, oxygen, and copper are examples of some of these 104 elements.

The structure of materials is explained by the fact that the forces of attraction between some atoms are strong enough when the atoms are in a close contact with each other. In fact, even certain unlike atoms exert strong attractive forces on each other. For example, an oxygen atom has a strong attraction for one or even two hydrogen atoms. The combined unit of two hydrogen atoms strongly attached to an oxygen atom is called a water molecule. One should remember that water is made up entirely of such molecules.

If some water vapour is subdivided down to the smallest particle that still has the chemical properties of water vapour, the result is a water molecule. Any substance made up of identical molecules containing dissimilar atoms is known to be compound.

It is important to note that the molecules of a solid or a liquid are in a rather close contact with each other. One can say that solids and liquids are almost incompressible. Gases, on the other hand, consist of well-separated molecules.

Vocabulary:

matter – вещество, материя
particle – частица
empty – пустой
indivisible – неделимый
solid – твердый, плотный
solar – солнечная
to revolve – вращаться
nucleus – ядро
to behave – вести себя
force – сила
attraction – притяжение
extremely – чрезвычайно
to exist – существовать
earth – земля
entirely – полностью

hydrogen – водород
oxygen – кислород
carbon – углерод
certain – определенный
to exert – оказывать влияние
vapour – пар; туман, дым
to subdivide – подразделять
property – свойство
compound – смешивать, соединять; сложный
incompressible – несжимаемый

Exercises

15.1 Read the following international words:

molecule, atom, philosopher, minute, chemical, structure, hydrogen, microscope, technique, electrons, system, orbit, contact.

15.2 Answer the following questions:

1. What did Democritus state?
2. What does the word "atom" mean?
3. What is the atom like?
4. What is the atom compared with?
5. Can you give examples of some chemical elements?
6. What do you call a water molecule?
7. What do you call a compound?
8. Are gases incompressible?

15.3 Translate the following sentences:

1. Мне казалось, что этот опыт провести нельзя.
2. Интересно заметить, что атом похож на маленькую солнечную систему.
3. Говорят, что были найдены новые элементы.
4. Следует помнить, что электроны — отрицательные заряды электричества.
5. Можно сказать, что сейчас существует более 100 элементов.
6. Было найдено, что молекула воды состоит из двух атомов водорода и одного атома кислорода.

7. Первоначально считали, что атом неделим.

15.4 State if the following sentences are true to the fact or false. Correct the false sentences.

1. Democritus stated that all matter is made up of molecules.
2. Originally the atom was believed to be a solid mass.
3. Many years ago it was shown that the atoms behave like the planets in the solar system.
4. There are about 92 elements.
5. A water molecule consists of oxygen atoms.
6. Not any substance made up of identical molecules containing dissimilar atoms is known to be compound.

16 The thermometer and the measurement of temperature

Fig. 16-1. Thermometer

The temperature of a body is a measure of the kinetic energy of its molecules, that is, a measure of molecular motion. If a hot body and a cold one are placed in contact with each other, a state of thermal equality will finally be reached. Both bodies are then said to be at the same temperature. The temperature of a body can be defined exactly only if we know how to compare it with some other standard temperature.

Any property of matter which varies continuously with the temperature change might be used to measure temperature. In every case, however, the measurements are based on the selection of two standard temperatures and the subdivision of the interval between them into a definite number of divisions, or degrees.

A thermometer, as its name indicates, is an instrument to be used for "metering" or measuring temperature (fig. 16-1). Using a thermometer, graduated according to certain standards, it is possible to find the temperature of a given body in units known as degrees. To make the first thermometers was not an easy thing. At present, however, they are made in various ways. The common type is the "liquid-in-glass" thermometer so commonly used to indicate temperatures. Mercury is generally used as the liquid in such thermometers because of its high boiling heat and coefficient of linear expansion. However, other liquids can be used as well and sometimes they are more desirable than mercury whose freezing point is comparatively high.

Certain properties of matter appear to be always the same under definite conditions. For example, the freezing point of pure water at a pressure of one standard atmosphere is assumed to be invariable. The temperature of freezing water is, therefore, a definite, fixed temperature which can be used as a standard. The temperature at which pure water boils at normal atmospheric pressure is always the same, so we have the boiling point as another definite, fixed temperature to be used as a standard.

Two temperature scales, namely, the Fahrenheit scale and the Centigrade scale are used. The Fahrenheit scale commonly used in the United States and in England is defined by the fact that the freezing point of water is at 32° F and the boiling point at 212°. There are, therefore, one hundred and eighty Fahrenheit degrees between these two fixed temperatures.

There are different types of thermometers

The temperature scale generally used in scientific work is called the Centigrade scale. The Centigrade scale is the official scale of temperature used in our country. We also know it to be the official temperature scale used in most countries. One may define this temperature scale by saying that the freezing point of water is represented by zero degree Centigrade (0°C) and the boiling point of water — by one hundred degrees Centigrade (100°C). Thus, to obtain this scale it is necessary to divide the interval between the freezing point and the boilng point of water into 100 equal divisions or degrees, the zero representing the freezing point of pure water at normal atmospheric pressure.

Vocabulary:

equality – равенство
to reach – достигать
to vary – изменяться, менять
meter – счетчик
degree – градус, степень
to measure – измерять
to graduate – градуировать
mercury – ртуть
linear – линейный, вытянутый в длину
expansion – расширение
desirable – желательный
to freeze – заморозить,
condition – условие
pure – чистый
pressure – давление
to divide – делить

Exercises

16.1 Read the following words:

measurement, equality, touch, qualitatively, liquid, mercury, pure, atmosphere, entirely, contact, standard, instrument, coefficient, interval.

16.2 Answer the following questions:

1. What do you call the temperature of a body?
2. What will happen if a hot body and a cold one are placed in contact with each other?
3. Is it possible to define the temperature of a body?
4. What is a thermometer used for?
5. What liquid is used in a "liquid-in-glass" thermometer?
6. What temperature scales do you know?
7. Where is the Fahrenheit scale commonly used?
8. What temperature scale is used in our country?

9. What does the zero represent on the Centigrade scale?
10. What is the freezing point of water?

16.3 Complete the sentences with words given below:

body, to expand, units, to measure, law, invariable, gases, scale

1. A thermometer is an instrument that is generally used …the temperature.
2. To heat a body we place it in contact with another … at a higher temperature.
3. We expect most bodies … when heated.
4. The freezing point of pure water at a pressure of one standard atmosphere is assumed to be ….
5. In this case we should refer to the …of thermodynamics.
6. To measure temperature it is necessary to choose some kind of temperature ….
7. … are known to expand on heating.
8. Using a thermometer it is possible to find the temperature of a given body in …known as degrees.

16.4 Translate the following words and define their part of speech:

1. vary, various, variable, invariable, variation;
2. measurable, measurement, measure, immeasurable;
3. quality, qualitative, qualitatively, qualify;
4. definite, define, definition, indefinite;
5. division, divide, subdivision, indivisible;
6. comparison, compare, comparable, comparatively.

17 Specific heat

If we mix a number of substances that have different temperatures, "they will come to a common temperature between that of the hottest substance and the coldest. The mixture being properly insulated, the amount of heat lost by the hotter substances must be equal to that gained by the colder ones.

A certain mass of water at 0°C being mixed with an equal mass of boiling water at 100° C, the temperature of the mixture is approximately 50° C. The heat given out by the hot water when it is cooling from 100 to 50° C is, therefore, approximately the same as the heat necessary to warm an equal mass of water from 0 to about 50° C. The energy lost by the hot water is equal to the energy transferred to the cold water.

A piece of copper at 100° C being placed in an equal mass of water at 0°C, the temperature of the mixture is only about 9°. Hence, copper has to cool through approximately 91° C in order to raise the temperature of an equal mass of water through about 9° C. Copper has a smaller specific heat than water.

Suppose you take a piece of iron and a piece of aluminium of equal weight and heat both the iron and the aluminium to the same temperature of 100° C. Placing them both on a piece of ice, you will observe that the aluminium melts more ice than the iron does. The aluminium gives up more calories than the iron though both were cooled from 100 down to 0°C, the temperature of the ice. More calories are also required to heat the aluminium to 100° C than to heat the iron. Experiments show that equal weights of different materials require different quantities of heat to raise their temperatures 1°C. To describe these facts, we say that aluminium has a greater specific heat than iron. The quantity of heat measured in calories which will raise the temperature of 1 gr of a substance 1°C is called the specific heat of that substance. In other words, the specific heat of any substance is defined as the number of calories that is required to raise the temperature of one gram of the substance one degree Centigrade. The following table lists seven substances and their specific heat values.

Substance	Specific heat calories per gram per degree at 0° Centigrade
Water	1.00
Ice	0.5
Aluminium	0.2

Iron	0.11
Copper	0.091
Silver	0.055
Mercury	0.033

Water has a higher specific heat than most other common substances, the specific heat of iron being approximately one-ninth that of water.

Vocabulary:

specific – особый, особенный; определенный
to fall (fell, fallen) – падать
mixture – смесь
properly – свойство
approximately – приблизительно
equal – равный
to gain – получать, достигать
copper – медь
to suppose – предполагать
to melt – плавить
ice – лед
quantity – количество
table – таблица
number – количество
to require – требовать
value – величина

Exercises

17.1 Read the following words:

specific, slightly, molecule, further, exchange, quantity, amount, equation, approximately.

17.2 Answer the following questions:

1. What do we call a "calorie"?
2. What will happen if we mix a number of substances that have different temperatures?
3. Can energy be created and lost?
4. What do you call the specific heat of a substance?
5. What is the specific heat of water?
6. Does aluminium heat up faster than iron?
7. Why can aluminium give up more calories than iron?
8. What is the specific heat of iron?

17.3 Translate the sentences. Mind <u>one:</u>

1. Some substances are efficient conductors, others, poor ones.
2. There are many insulating materials from which one may choose.
3. One uses special devices to measure current, voltage and resistance.
4. The new method proved to be much more efficient than the old one.
5. One knows that these installations do not operate on nuclear power.
6. One must choose only one of those variants.

17.4 Change the sentences into questions:

1. There are various types of nuclear reactors.
2. The use of underground transmission lines must be increased.
3. The energy industry is undergoing considerable development.
4. A gas – cooled reactor is a nuclear reactor in which the coolant is a gas.
5. Radioactive wastes damage man and his generation.

17.5 Translate the following sentences, paying attention to the words in bold type:

1. If two bodies are placed in contact with each other, the temperature of the hot body falls while **that** of the cold **one** rises.
2. Every **one** knows **that** it takes more heat to raise the temperature of a pound of water 10° C than a pound of iron.
3. We know **that** the temperature of an object does not indicate the amount of energy contained in **that** object.
4. Rihrnan established the rule **that** defines the temperature of a mixture

consisting of two unequal masses of water at different temperatures.

5. **That** water boils at 100° C is a well known fact.

6. In my opinion **one** experiment is more important than a thousand suppositions.

•

18 Sources of heat

One can derive heat from work by using mechanical energy, from chemical reactions by using chemical energy, from electricity by using electrical energy, and from the sun by using radiant energy.

Heat is a form of energy, thus, studying heat mainly consists in studying the changes of energy. Note that in every above-mentioned case, it is work that produces heat, directly or indirectly.

One of the most important uses of electricity is the production of heat. Electricity is used as a source of heat in furnaces where extremely high temperatures are needed for tempering metals. The electric lamp widely used for the generation of light also depends upon the heating property of electricity. The electric arc is used for welding two or more pieces of metal, a tremendous amount of heat being present when the current moves from one electrode to the other in a welding machine.

Let us take another example, when heat is produced by chemical energy. By burning coal in the boiler furnace, we transform chemical energy into heat. The heat energy of hot gases is transferred to the water in the boiler unit. That heat transfer speeds up the motion of water molecules and water starts vaporizing. If steam is directed now to a steam engine, it will exert a pressure on the pistons of that engine and will perform useful work. In such a manner, chemical energy can be transformed into heat, heat being transformed into mechanical energy.

Work is obtained from the energy of molecular motion. Heat energy is the energy of molecular motion. Work can produce heat, heat can do work. We have had many examples of these facts. It was found that one calorie of heat is always the equivalent of about 427 gram-metres of work.

We do not ordinarily perform gram-metres of mechanical work to obtain heat. Nature has provided us with other sources of heat.

Fig. 18-1. A truck that runs on solar power.

The sun is the original source of all energies stored in fuels. It steadily sends out the greatest amount of radiant energy (fig.18-1). The very small portion of that energy falling on the earth is, nevertheless, a tremendous quantity.

Plants are also useful sources of energy thanks to their storing the sun's radiation in chemical form. Our fuels of to-day are the plants of a remote past.

The ground as heat source

Vocabulary:

to derive – получать, извлекать
mainly – главным образом
to consist – состоять

to note – замечать
important – важный
source – источник
furnace – печь
extremely – чрезвычайно
high – высокий
to need – нуждаться, требовать
to temper – метал. отпускать; закалять
widely – широко
generation – тех. генерация, образование
property – свойство
arc – дуга
to weld – тех. сваривать(ся), сплачивать
tremendous – огромный
to burn – гореть, сжигать
steam – пар
to vaporize – испаряться
engine – двигатель
to exert – оказывать давление; тех. вызывать (напряжение)
piston – поршень
to perform – выполнять
to obtain – получать, достигать
fuel – топливо
ordinary – обычный
portion – часть, порция
nevertheless – тем не менее

Exercises

18.1 Read the following words:

source, mechanical, chemical, either, through, electricity, furnace, extremely, machine, exert, pressure, molecular, require, generation.

18.2 Answer the following questions:

1. How can one derive heat?

2. Is heat a form of motion?
3. What forms of energy do you know?
4. What is one of the most important uses of electricity?
5. Does the electric lamp depend on the heating property of electricity?
6. Can you find an example when heat is produced by chemical energy?
7. What is the original source of all energies stored in fuels?
8. What does the sun steadily send out?

18.3 Read about energy resources of today. Write some questions about the text and ask your groupmate to answer them .

Energy Resources of Today

People are energy-rich today. Solar energy is considered to be a potentially limitless source of clean energy. The waters of the world contain potential fuel – in the form of a special isotope of hydrogen – deuterium. It is sufficient to power fusion reactors for thousands of years.

18.4 Translate the following words:

heat — to heat; warm — to warm; light — to light; part — to part; water — to water; form — to form; direct — to direct; work — to work.

18.5 State if the following sentences are true to the fact or false. Correct the false sentences.

1. One can derive heat from the sun by using mechanical energy.
2. Heat is a form of work.
3. Electricity may be used for the production of heat.
4. The electric arc is used for heating.
5. Electricity is obtained from the energy of molecular motion.

19 The effects produced by heat

The effects produced by heat are interesting and of great practical importance. Here is the list of some examples that heat can do.

1. As heat is absorbed by a body, the temperature of the body generally rises. For example, water in a kettle over a gas stove rises in

temperature while absorbing heat.

2. Heat absorbed by a solid may cause the solid to melt or to change from a solid to a liquid state. Heat to be absorbed by a liquid causes the liquid to evaporate, that is, to change from a liquid state into a vapour. For example, ice melts while heated and the continued addition of heat changes water into steam.

3. The size of an object nearly always increases when it is heated. As mentioned, mercury expands in a thermometer. Bodies not only increase in length when heated but also expand in all directions.

4. It is heat that causes many chemical changes. The preparing of our food is an example (fig. 19-1). Many chemical reactions in the laboratory are also started due to the application of heat.

Fig. 19-1. Very good heat conduction

5. Heat may produce electric energy when fuel is used or provided two different metals in contact are heated.

6. It is heat that enables us to do work, utilizing suitable machines. Fuel is burned to produce steam. The steam, in its turn, is used to operate steam engines and turbines.

7. Motor-cars, diesel trains, and airplanes burn liquid fuels in the cylinders of their engines, producing heat which is converted into kinetic energy of motion.

8. As said before friction produces heat but the heat produced by friction is usually considered as lost heat or useless work.

9. Finally, heat produces physiological effects both in plant and animal life. It is the effect of heat that keeps a human body at a nearly constant temperature, even though that of the air may change widely.

When a substance is placed over a fire, it may:

(1) become steadily hotter (we say that its temperature rises);

(2) melt, thus changing from a solid to a liquid;

(3) boil and finally evaporate, thus changing from a liquid to a vapour;

(4) simply burn or undergo a chemical change, being transformed into something else;

(5) become red-hot or white-hot, thus giving out light

A poker placed in a fire becomes hot, expands a little, and goes red. Ice in a kettle placed over a fire melts, then gets warmer, and finally boils. Paper held over a fire either burns or, at least, changes to a brown colour. It has undergone a chemical change since, even if cooled, it will not return to its original condition.

Vocabulary:

though – хотя
measurement – измерение
effect – действие, эффект
to absorb – поглощать
kettle – чайник
stove – печь, плита
solid – твердый; физ. твердое тело
state – состояние, положение
to evaporate – испаряться
vapour – пар
to expand – расширяться
length – длина
direction – направление
application – применение
suitable – подходящий
plant – растение; завод
to undergo – подвергаться
to boil – кипеть
to return – возвращать(ся)
poker – кочерга
fire – огонь

Exercises

19.1 Read the following international words:

temperature, examine, thermometer, utilize, physiological, kinetic, effect, electric, machine, chemical, transform, laboratory.

19.2 Answer the following questions:

1. When does the temperature of a body rise?
2. Does ice melt while heated?
3. What happens to a solid when it is heated?
4. What causes a liquid to evaporate?
5. What kind of energy can be produced by heat?
6. Does friction produce heat?
7. What keeps a human body at a nearly constant temperature?
8. What happens to a substance which is placed over a fire?
9. What is the boiling point of water?

19.3 Translate the following sentences:

1. Ice melts when heated.
2. A liquid becomes hotter, boils and finally evaporates while heated.
3. When placed over a fire, a substance becomes hotter.
4. Paper either burns or at least changes to a brown colour if held over a fire.
5. Liquid fuels, if used in the cylinders of diesel engines, produce heat.
6. If produced by friction, heat is usually considered as useless work.
7. When cooled below zero water changes into ice.
8. When utilized in suitable machines, heat enables us to do work.
9. Although useless in some cases, friction is sometimes desirable.

19.4 Find in the article antonyms for the following words:

to cool, to rise, to increase, solid, useless, hot, original.

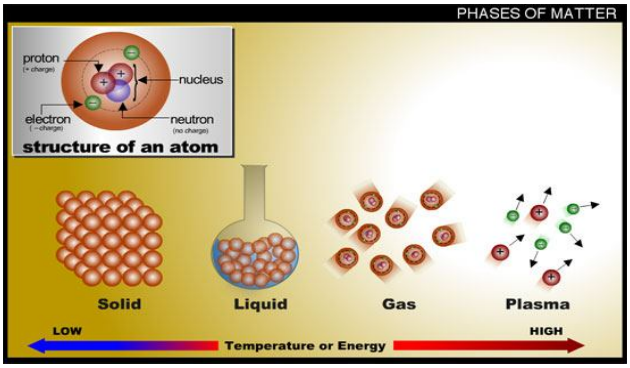
19.5 Give all the English synonyms for the following words:

скорость, различный, точный, применять, продолжать, соединять, определять, помогать, исследовать, техника.

20 Four states of matter: solid, liquid, gas, plasma

Many substances can exist in more than one of the four states. That state depends on the substance itself as well as on its volume, temperature and pressure. Ordinary air, for example, condenses completely to a liquid if the temperature is lowered to 196° below zero Centigrade. It would become a solid provided the temperature were further lowered to -218° C.

If we think of the substance that we call "water", we generally think of it as a liquid.



Four states of matter

It does not mean that that is the only possible state in which water does exist. That the liquid state is the normal state for water is a well-known fact. But water, as anyone must know, can also exist in a gaseous state, i.e., as steam and as a solid, i. e. ice.

The same number and kind of molecules are present in a kilogram of water, steam or ice. However, these molecules move differently in each of the above mentioned states, hence, their widely varying characteristics.

The molecules of solids are able to move only through a limited range. The motion of the molecules of a solid is harmonic in type. The molecules move between fixed limits back and forth on either side of an "average" position and seldom pass outside those limits. It is a solid that has both volume and shape.

The molecules of liquids are in a state of constant, random motion. However, there are attractive forces exerted on each molecule by the surrounding molecules. Thus, a given molecule is free to move within the liquid itself but is not likely to leave its surface unless it moves very fast. The rather large forces of attraction exerted on that molecule by the surrounding molecules serve to fix the volume of a given liquid although its shape is changeable.

Experiment shows us that there is very little attraction between the molecules of any gas. The gas molecules move with an almost perfect freedom, very little force being exerted on one molecule by the molecules surrounding it. The molecules move rapidly in every direction, colliding with one another, expanding to occupy every portion of the container, bombarding the walls of the container. Gases, therefore, have no fixed volume or shape. Their volume and shape depend on the vessel that contains them.

The fourth state of matter, the plasma, consists of neutral atoms, ionized atoms and electrons.

Vocabulary:

universe – земля, вселенная
root – корень
to compare – сравнивать
possible – возможный
volume – объем
ordinary – обычный
to condense – сгущать(-ся), конденсировать
steam – пар
range – ряд, линия; предел, амплитуда
harmonic – гармоничный
shape – форма
random – наугад; беспорядочный
to surround – окружать
surface –поверхность
rapid – быстрый; скорый

ionize – хим. ионизировать

Exercises

20.1 Read the following words:

liquid, philosopher, taught, universe, earth, air, gaseous, respectively, substance, various, although, molecular, increase, cause, measure,

20.2 Answer the following questions:

1. What are the four states of matter?
2. What does the state of a substance depend on?
3. Does water exist in a gaseous state?
4. Why has a solid both volume and shape?
5. What does the shape of a gas depend upon?
6. What does the plasma consist of?
7. Do many substances exist in more than one of the four possible states?

20.3 Translate the following sentences:

1. If a solid is heated it will expand.
2. Were the tested liquid heated to 100° C, it would begin to boil.
3. On our planet, plasma has to be generated by special physical processes and under special conditions.
4. With a rise in temperature, molecular motion becomes more violent to overcome the attraction of the liquid and evaporates.
5. It is the molecules of liquids that are in a state of constant random motion.
6. Air condense completely to a liquid when the temperature is lowered to —196° C.
7. Life on our planet would be impossible unless there were water.

20.4 State if the following sentences are true to the fact or false. Correct the false sentences.

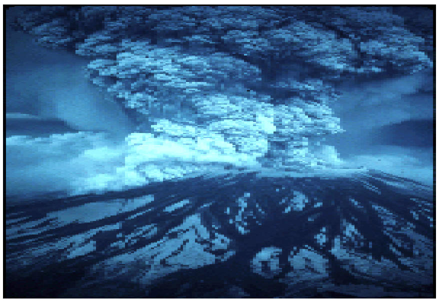
1. There are two states of matter, namely, liquid and gas.
2. Many substances exist only in one state.

3. The molecules of solids are in a state of constant, random motion.
4. There is very little attraction between the gas molecules.
5. The plasma consists of neutral atoms, ionized atoms and electrons.

21 Transmission of heat

There are three different types of heat transmission, namely:, conduction, convection and radiation.

Conduction. Heat may be transferred from a hotter body to a colder one by direct contact. Fast-moving molecules tend to speed up their slower neighbours on collision. We know that this method of heat transfer is called conduction. Thus, conduction is the flow of heat through an unequally heated body from places of higher to places of lower temperature, the latter being raised in temperature as the heat passes through them (fig. 21-1).



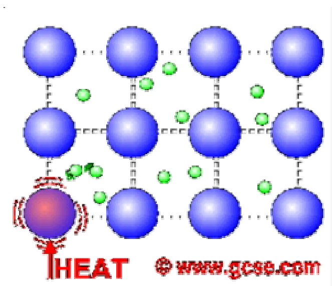


Fig. 21-1. Conduction

We have observed that some materials are good conductors of heat and others are poor conductors. Generally speaking, metals are excellent conductors, the best conductors of electricity being also the best conductors of heat. Thus, aluminium known as a good electrical conductor is likewise a good conductor of heat. On the other hand, materials like sand, asbestos, and still air are poor conductors of heat.

Convection. In gases and liquids another process of heat transfer is very effective, namely, convection. Convection is the transfer of heat by the motion of the hot body itself carrying its heat with it (fig. 21-2). A current of liquid or gas that absorbs heat at one place and then moves to another place where it mixes with a cooler portion of the fluid and loses heat is called a convection current. Convection occurs only in liquids and gases.

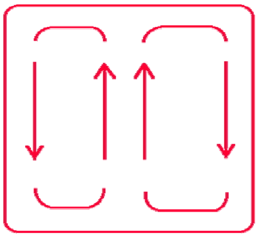
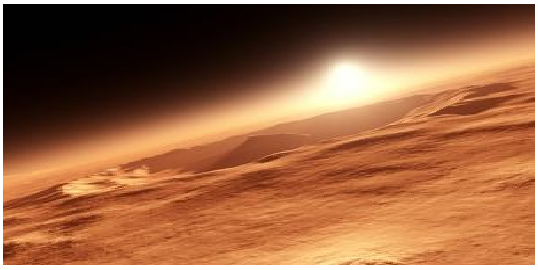


Fig. 21-2. Convection

Radiation. There is a third way by which heat travels, namely, radiation. We know the temperature of the sun to be intensely high. We also know that, when the sun shines on the earth, the earth is warmed. The passage of heat from the sun to the earth is found to take place by radiation. An important characteristic of radiation is that it can occur in a vacuum; it does not depend upon the presence of a substance. In addition to that, the space between the source of heat and the body to receive the heat does not rise in temperature.



Radiation

Vocabulary:

neighbour – сосед; ближний
collision – столкновение
flow – поток, течение
to pass – проходить
excellent – отличный
likewise – подобно; также

sand – песок
asbestos – асбест
effective – эффективный
to carry – нести, тащить
to occur – случаться, происходить
density – физ. удельный вес, плотность
toward – по направлению
to separate – отделять
by means – посредством
to require – требовать
medium – среда
to radiate – излучать
to emit – испускать, физ. излучать

Exercises

21.1 Read the following words:

transfer, through, air, liquid, occur, effect, circulation, , quantity, ice., current, distribute, passage, mercury, fire, temperature, touch, although, source, rough, surface, linear, pour, pressure,

21.2 Answer the following questions:

1. What types of heat transmission do you know?
2. What do you call conduction?
3. Are the best conductors of electricity also the best conductors of heat?
4. What is known as convection?
5. What is the difference between convection and conduction?
6. What good conductors of heat do you know?
7. What is radiation?

21.3 Translate these negative sentences into Russian. What is the difference between the English constructions and the Russian ones?

1. No charge can move in an open circuit.
2. No special equipment is necessary to carry out the experiment.

3. A current which doesn’t change it’s polarity is called a direct current.
4. A dry battery is a type of a small battery containing no free liquid.
5. Electrically safe locations are those where conditions causing extremely high danger of electric shock do not exist.
6. No electric device has only advantages. All of them have also disadvantages.
7. Nobody expected him to invent this device.

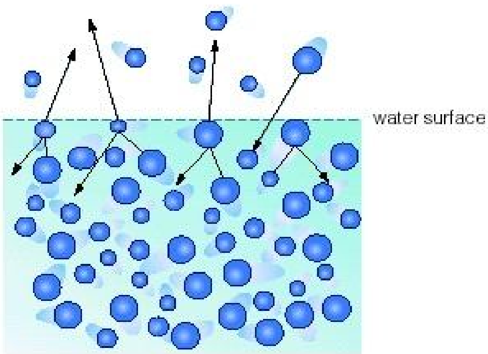
21.4 Translate the following sentences, paying attention to the functions of the infinitive:

1. To find the state of a mass of gas, we must know its volume, its pressure, and its temperature.
2. To convert heat directly into electrical energy is still a problem that should be solved.
3. Some liquids prove to be good conductors of electricity.
4. Heat is known to pass from a hotter body to a colder one.
5. The substances to be burned must be raised in temperature till the ignition point is reached.
6. We know heat to be a form of energy, but there was a time when it was supposed to be a kind of a substance which was believed to flow from a hotter body to a colder one.

21.5 State if the following sentences are true to the fact or false. Correct the false sentences.

1. Radiation plays an important part in the heating systems.
2. There are two types of heat transmission.
3. Liquids are very good conductors of heat.
4. Gases can conduct heat but their conductivity is very low.
5. When the sun shines on the earth, the earth is warmed.

22 Evaporation



During evaporation, the more energetic particles escape from the surface leaving the less energetic ones behind.

A liquid is known to increase in temperature when heat is applied. This statement is true up to a certain point called the boiling point of the liquid. When the boiling point is reached, however, adding heat to the liquid no longer raises its temperature. The added heat will then cause a change of state since the liquid will be transformed into a gas or a vapour.

Evaporation also called vaporization

Fig. 22-1. Evaporation

is the name given to the process which occurs when some of the molecules of a liquid tear themselves away from the liquid surface and escape into the air (fig. 22-1). These molecules form the vapour above the liquid. To tear itself away from the liquid, the molecule which leaves it should have a large amount of kinetic energy as the molecular attraction which tends to oppose this escape must be overcome by the molecule. Those molecules which escape must have greater energy than the average kinetic energy of the liquid as a whole.

If little ether is poured on to the hand, a sensation of cold is felt as evaporation takes place. This is because heat is absorbed from the hand to transform the liquid into vapour. The change of state from a liquid to a vapour involves absorption of heat, just as does a change from solid to liquid.

Different liquids evaporate at different rates because of differences in their molecular attractions and in their molecular speeds. Mercury, for instance, evaporates very slowly, ether vaporizing rapidly.

The rate of evaporation also depends on the area of the evaporating surface. That is why water will dry up from a large flat vessel much sooner than it will from a tall and narrow vase.

Evaporation takes place at all temperatures. There is another process, however, which takes place at a particular temperature and at which the process of vaporization is hastened by the constant heat application.

In the process of boiling, heat is constantly added to the liquid. The heat to be added increases the kinetic energy of the molecules, which is the same as saying that the temperature of the liquid starts rising. In the process of evaporation described above the phenomenon is a surface effect. The vapour molecules pass from the surface of the liquid into the air surrounding the liquid. Boiling is a similar process except that when a liquid boils evaporation takes place throughout the volume of the liquid, small bubbles of vapour forming within the liquid and additional vapour molecules joining each of the bubbles as it rises to the surface.

Vocabulary:

to apply – применять
to boil – кипеть
point – точка, отметка
to cause – вызывать, быть причиной
evaporation – испарение
to tear – срывать, отрывать(ся)
to escape – бежать; улетучиваться
to tend – направляться
to oppose – противопоставлять; сопротивляться, мешать
ether – *хим., физ.* эфир
rate – скорость; норма
area – площадь
flat – плоский
to hasten – спешить; торопить; ускорять
bubble – пузырь
to join – присоединяться
liquefaction – сжижение; разжижение
condition – условие
to obtain – получать
expansion – расширение

Exercises

22.1 Read the following words:

liquid, increase, cause, vapour, vaporization, occur, molecule, air, molecular, kinetic, pour, mercury, phenomenon, throughout.

22.2 Answer the following questions:

1. Does adding heat to the liquid always raise its temperature?

2. When does evaporation occur?
3. What do you call vaporization?
4. What does the change of state involve?
5. Why do different liquids evaporate at different rates?
6. What does the rate of evaporation depend on?
7. At what temperatures does evaporation take place?

22.3 Translate the following sentences, paying attention to the non-finite forms of the verb:

1. Such substances as glass melt gradually on being heated.
2. We know a solid body to have a definite shape.
3. The temperature being raised, the kinetic energy of a body is increased.
4. Adding heat does not always cause a rise in temperature.
5. Adding heat to a boiling liquid, we make it change its state without changing its temperature.
6. All fluids are expected to possess almost the same mechanical properties.
7. A well-known characteristic of radiation is that the space between the source of heat and the body to receive the heat does not rise in temperature.
8. Hot objects radiate much more heat than cold ones, the quantity of energy radiated increasing very rapidly with increased temperature.
9. You will not make water boiling in an open container any hotter in spite of your using a hotter flame.

22.4 Find synonyms among the following words and arrange them in pairs:

fluid, movement, evaporation, matter, liquid, speed, to obtain, motion, rate, substance, to get, vaporisation.

22.5 Find antonyms among the following words and arrange them in pairs:

to contract, rapid, to start, rise, different, heat, indirectly, slow, decrease, small, to expand, the same, increase, liquid, high, fall, large, solid, cold, low, to stop, directly.

22.6 Translate the following sentences and define the functions of the word "that".

1. **That** water boils at 100° C is a well-known fact.
2. Our great scientist Lomonosov was among the first to state **that** heat phenomena were due to the motion of molecules.
3. The physics of bodies at rest is much simpler than **that** of bodies in motion.
4. A barometer is an instrument **that** is used for measuring air pressure
5. .The current flowing through the wire heats **that** wire.

22.7 Translate the following sentences, paying attention to the modality:

1. The temperature of the water does increase when heat is applied to it.
2. Let's heat the kettle of water to the boiling point temperature!
3. The temperature of the evaporating water will be cooler than that of the surrounding air, unless heat is provided from an external source.
4. Naturally, warmer water should evaporate more rapidly than cold.
5. It is the application of additional heat that speeds up the formation of steam bubbles.
6. It should be noted that there is no definite value for the specific heat of vapour.
7. If we heat a solid body or a liquid, they will expand.

23 Boiling

Fig. 23-1. Boiling

When one puts a kettle full of water on a stove and lights the gas, the vapour pressure of the water starts increasing. More and more of the water molecules escape from the liquid with greater speed. Finally, the water will begin boiling. Boiling occurs when vapour is formed at the bottom of the kettle as well as at the top. We know that it is possible only when the vapour pressure of the water is as great as the pressure of the atmosphere (fig. 23-1).

The turbulent motion of the boiling water is caused by bubbles of vapour rising through the water. The boiling point being reached, the vapour pressure no longer increases.

After the boiling point has been reached, the temperature of the water cannot be increased any more even if more heat were added. It is well known that the average speed of the molecules remains the same, no matter how hot the stove is. The heat that is supplied is used to vaporize the water, that is, to separate the molecules from each other, overcoming the attractive forces that hold them together in the liquid.

When water is boiling in the kettle, we generally say that we see steam coming out of it. However it has already been mentioned that we see fine water particles but not steam. Steam itself is invisible. It is the condensed steam in the form of fine particles of water that we see.

Vocabulary:

to boil – кипеть
to occur – случаться, происходить
bottom – дно
top – вершина; верхняя поверхность
turbulent – бурный, беспокойный
bubble – пузырь
to reach – достигать
average – средний
to remain – оставаться
matter – дело, случай
to separate – отделять
to overcome – преодолевать
attractive - привлекательный; привлекающий
to hold (held, held) – держать
fine – зд. прозрачный
particle – частица
steam – пар
pure – чистый, безпримесный
dissolve – растворять(ся), испарять(ся)

Exercises

23.1 Read the following words:

liquid, vaporize, molecule, pressure, cause, through, require, average, attractive, separate, invisible.

23.2 Answer the following questions:

1. When does the vapour pressure of the liquid increase?
2. When does boiling occur?
3. When is boiling possible?
4. What happens when the boiling point is reached?
5. Does the vapour pressure increase or decrease when the boiling point is reached?
6. Is steam visible?

23.3 Translate the following sentences:

1. The student is asked to describe the process of boiling from beginning to end.
2. It may happen that many of the evaporated molecules finally return to the surface of the liquid and recondense.
3. If a solid body or a liquid are heated they usually expand.
4. It is known that liquids and gases take the shape of the vessel which contains them.
5. They say that heated liquids expand more than solids do when heated.
6. One should consider the problem from the standpoint of vapour pressure.
7. It is easy to understand why warmer water should evaporate more rapidly than cold.
8. Water vapour and steam are known to be completely invisible.
9. One can say that a liquid does not become hotter as it continues to boil.
10. It is important to remember the basic laws of thermodynamics.

23.4 Translate the following sentences, paying attention to the words in

bold type:

1. The increase in motion **causes** the molecules to collide with each other.
2. The above phenomenon may occur due to two **causes.**
3. Heat **causes** many chemical changes in substances.
4. Bending the wire quickly **causes** part of the molecules to move about more rapidly, so that the temperature of the metal is increased.
5. A continuous, random motion of milliards upon milliards of molecules is the **cause** of gas pressure.
6. As is well known, it is quite possible to operate powerful engines by **means** of atomic energy.
7. To our two **means** of heat transfer we shall add a third very important method, namely, radiation.
8. As the transfer of heat by **means** of conduction or convection requires the presence of a substance, heat radiation can occur in a vacuum.
9. What does the term "boiling" **mean**?
10. The words "average" and "**mean**" are synonyms.

23.5 Translate the following word combinations:

temperature difference, heat content, mercury thermometer, water particle, temperature sensation, vapour pressure, evaporation problem, water vapour, saturated vapour pressure, solid fuel element, steam bubble, liquid surface, steam engine.

24 The steam turbine

Fig. 24-1. The steam turbine

Perhaps the most widely used source of power in large power plants is the steam turbine (fig. 24-1). A steam turbine is known to operate by virtue of the heat which it derives from steam and which it converts into mechanical work. Any apparatus converting heat into mechanical work is considered to be a heat engine. Thus, the steam turbine may also be considered a heat engine. It is different from a reciprocating heat engine, however, in its manner of converting heat into mechanical work.

A steam turbine does mechanical work by virtue of the velocity with which steam strikes or leaves its moving parts. The steam attaining its velocity by issuing an opening, its kinetic energy may be converted into mechanical work by suitably deflecting its current.

One modern type of steam turbine is made up of a number of discs with blades set in the rim of the disc, each disc being fixed to a central shaft. The steam is directed first against the blades of the first disc and gives up part of its energy to that disc. The steam is deflected by the blades in this case, and then by means of stationary blades it is turned so that it will strike the blades of the next disc. Thus, a series of movable and fixed discs provided with blades, which change the direction of the steam each time it strikes a blade, causes the steam to impart energy to the rotating arrangement several times before its leaving the turbine.

Such steam turbines are considerably more efficient than ordinary reciprocating steam engines. Furthermore, they can be made of very large sizes, capable of producing several hundred thousand kilowatts. The efficiency of a 100,000-kW steam turbine may be as great as 38% and that of a 200,000-kW turbine —43%, respectively.

A steam turbine under construction

Vocabulary:

source – источник
plant – завод
by virtue of smth. – посредством чего-либо
to derive – получать, извлекать
to consider – рассматривать, считать
reciprocating-engine – поршневой двигатель
to issue – происходить, получаться
considerable – значительный
velocity – скорость, быстрота
liberate – освобождать; хим. выделять
to strike – бить, ударять
to attain – достигнуть, добиться
to deflect – отклонять(ся)
blade – лопасть (винта, весла)
rim – ободок, край; обод (колеса)
to fix – крепить
shaft – тех. вал, ось, шпиндель
series – ряд; серия
to impart – давать; передавать
arrangement – расположение; устройство
capable – способный

Exercises

24.1 Read the following words:

source, power, turbine, convert, reciprocating, mechanical, through, issue, cause, furthermore, efficiency, engine development, industry, machine.

24.2 Answer the following questions:

1. What is the most widely used source of power in large power plants?
2. How does a steam turbine operate?
3. What do you call a heat engine?
4. What does a modern type of steam turbine consist of?

24.3 Translate the following sentences, paying attention to the non-finite forms of the verb:

1. Locomotives and small stationary steam engines seldom convert into mechanical work as much as 10 per cent of the energy to be developed owing to the burning of fuel.
2. The steam expanding, its volume is increased.
3. By reducing the pressure range in each cylinder, a more uniform temperature is maintained in the cylinder itself.
4. The old reciprocating engine was believed to be the world's principal source of mechanical work.
5. Converting heat directly into electricity without using machines is one of the complicated engineering problems.
6. In spite of the gases having been compressed, they return to their original volume as soon as the applied force has stopped acting.
7. After reaching the boiling point, the water temperature cannot be increased, in spite of our adding more heat.
8. To turn a substance from one state to another it is necessary to add or to remove a definite amount of heat.
9. To tell when an apparatus or a machine is generating a current does not present any difficulty.
10. We expected the discovery of the plasma to have produced great changes in industry and such was really the case.

24.4 Form new verbs using the prefix "re-" and translate them:

to condense, to consider, to turn, to write, to make, to construct, to move, to gain, to arrange, to organize.

24.5 Define the part of speech of the following words and translate them:

real, engine, invisible, circulation, ceaseless, completely, evaporate, liquid, different, fast, nearly, continuous, surround, attraction, molecular.

25 Fuels

The fuels used in industry are either solid, liquid or gaseous. In speaking of "fuel" it is still the universal practice to mean the combustible material which in conjunction with atmospheric oxygen, forms the source of heat. Actually the fuel in the ordinary sense is only one of two components needed for the generation of heat by combustion. Air being the source of the oxygen required to produce the combustible mixture is, therefore, equally a part of the fuel, as are the other materials already mentioned. Thus, an air jet to be introduced into an atmosphere of, say, coal gas will burn in an identical manner to a gas jet in air. Excess of either of these components beyond the correct proportions is expected to lead to waste of heat.

A feature common to all industrial fuels is that the basic combustible is carbon and, with the exception of blast-furnace gas, this is combined in various proportions with hydrogen together with small portions of oxygen and sulphur. Noncombustible components are practically only met with in the case of solid fuels, and go to form the ash residue after the combustible matter has been consumed. There will also be a widely varying percentage of moisture associated with solid fuels when delivered and fired.

Solid fuels are composed, from the practical point of view, of "fixed" carbon, volatile matter, sulphur and moisture. The fixed carbon, the volatile matter and, to a minor extent, the sulphur compose the combustible matter, the classification of solid fuels being usually based upon the ratio of volatile matter to the fixed carbon.

The volatile matter is that proportion of the fuel which is distilled and gasified on heating to a temperature of 900° C, without access of air, leaving a residue of solid coke consisting of carbon and the incombustible ash and a portion of the sulphur. The fixed carbon is that remaining in the coke after distillation of the volatile matter. It is determined by complete combustion of the coke in a stream of oxygen so that only the ash remains.

Natural fuels like coal, gas and oil are being rapidly exhausted. The application of atomic power is becoming increasingly broader because at present it is the only known potential capable of meeting mankind's power requirements. The power obtained from atomic reactions has been applied to various fields of man's peaceful activity.

Fossil fuels

Vocabulary:

fuel – топливо, горючее
combustion – горение, сгорание
conjunction – соединение, связь; совпадение
to need – нуждаться
mixture – смесь
therefore – поэтому, следовательно
jet – струя (воды, газа и т.п.); реактивный
excess – избыток, излишек
beyond – вдали; вне, сверх, выше
feature – особенность, черта
carbon – углерод
exception – исключение
blast-furnace – домна, доменная печь
sulphur – хим. сера
ash – зола, пепел
residue – остаток; хим. осадок
to consume - потреблять
moisture – влажность, сырость
to deliver – доставлять; передавать; освобождать
volatile – хим. летучий, быстро испаряющийся
access – доступ; проход
coke - кокс

to exhaust – истощать; исчерпывать

Exercises

25.1 Read the following words:

fuel, industry, universal, practice, oxygen, source, air, require, mixture, either, feature, hydrogen, sulphur, moisture, acquire, exposure, vague.

25.2 Answer the following questions:

1. What fuels are used in industry?
2. Is fuel a combustible material?
3. Does fuel form the source of heat in conjunction with atmospheric oxygen?
4. What feature is common to industrial fuels?
5. What are solid fuels composed of?
6. Why is the application of atomic power becoming important?
7. What fuels are being exhausted?

25.3 Translate the following sentences, paying attention to the words in bold type:

1. All bodies **either** radiate heat **or** absorb waves from other bodies.
2. Dark surfaces are **either** good radiators when hot **or** good absorbers when cold.
3. The motion of the molecules of a solid is harmonic, the molecules moving between specific limits on **either** side of an average position and seldom passing outside those limits.
4. Gases have **neither** size **nor** shape of their own.
5. **Neither** of these devices will be required for the experiment in question.
6. Potential is **neither** a force, **nor** a pressure.

25.4 Form adjectives from the following nouns:

gas, liquid, universe, industry, combustion, practice atmosphere, heat, moisture, importance, base, variation, freedom.

25.5 State if the following sentences are true to the factor false. Correct the false sentences.

1. In speaking of "fuel" we mean the combustible material which in conjunction with atmospheric oxygen, forms the source of heat.
2. Non-combustible components are only met with in the case of gaseous fuels.
3. Solid fuels are composed of oxygen, hydrogen and sulphur.
4. Moisture is removed from fuel only by exposure to a temperature of about 112°F.
5. If the fuel is allowed to heat, it will once more take up inherent moisture.

26 Energy from fossil fuels

Coal, oil and natural gas are the three kinds of fossil fuels that we have mostly depended on for our energy needs, from home heating and electricity to fuels for our automobiles and mass transportation. They are limited in supply and will be depleted one day. There is no escaping this conclusion. The problem is, fossil fuels are non – renewable.

The total world energy demand is for about 400 quadrillion British Thermal Units – or BTUs – each year. (Source: US Department of Energy). That's 400,000,000,000,000,000 BTUs!

Oil, coal and natural gas supply nearly 88% of the world's energy needs, or about 350 quadrillion BTUs. Of this amount oil provides about 41% of the world energy supplies, or about 164 quadrillion BTUs. Coal provides 24% of the world energy, or 96 quadrillion BTUs, and natural gas provides the remaining 22%.

Fossil fuels mining and oil production can and has caused irreparable damage to our environment. We destroy ecosystems while mining fossil fuels and while using them. Oil spills have devastated ecosystems and coil mining has stripped lands of their vitality. Burning fossil fuels creates carbon dioxide, the warming. Combustion of these fossil fuels is considered to be the largest contributing factor to the release of greenhouse gases into the atmosphere. Air pollution is a direct result of the use of fossil fuels, resulting in smog and the degradation of human health and plant growth.

Vocabulary:

combustible – сжигаемый
quadrillion – мат. квадрильон
mining – разработки
release – утечка, выброс, эмиссия
deplete – истощать, исчерпывать
non – renewable – невозобновляемый
damage – вред, ущерб
destroy – разрушать

Exercises

26.1 Read the following words:

automobiles, transportation, renewable, quadrillion, irreparable, damage, environment, ecosystems, combustion, air pollution, degradation.

26.2 Answer the following questions:

1. What kind of fossil fuels do we depend on?
2. What is the environment impact of fossils?
3. What is BTU? What is it equal to?
4. How big is the part of fossils in meeting the world's energy needs?

26.3 Complete the sentences with words given below:

carbon dioxide, demand, supply, sources, degradation, damage, ecosystems.

1. We destroy …while mining fossil fuels and while using them.
2. Burning fossil fuels creates …, the warming.
3. Air pollution is a direct result of the use of fossil fuels, resulting in smog and the … of human health and plant growth.
4. Fossil fuels mining and oil production has caused …to our environment.
5. The total world energy … is for about 400 quadrillion BTUs each year.

6. . Fossil fuels are limited in … and will be depleted one day.
7. Biomass energy, or energy from burning plants and other organic matter, is one of the man's earliest of energy.

26.4 Translate the following words and define their part of speech:

1. to vary, various, variable, invariable, variation, variation;
2. to pollute, pollution, pollutant;
3. new, to renew, renewable, nonrenewable;
4. to contribute, contribution, contributory, contributor;
5. to divide, division, subdivision, indivisible;
6. to move, movement, moved, movable.

PART 3. ELECTRICITY AND MAGNETISM

27 Lines of force

Faraday first represented the electric field around an electrically charged body by means of lines which he called lines of force or lines of electric intensity (fig. 27-1). These lines are so drawn that at every point in the field the direction of the line tangent to the line of force in this point coincides with the direction of the intensity vector at that point. Thus, a positive unit of electric charge will tend to move along a line of force in the direction of the electric intensity, and a negative unit of charge tends moving in the opposite direction.

It is obvious that two lines of force can never meet, for then we should have the intensity at the point of meeting acting in two directions at once. In addition to that, we know of their being continuous at long as there exists a dielectric medium.

At any rate, one should always remember that lines of force do not really exist and that they by no means indicate the structure of the medium. We use these lines of force, as did Faraday, in order to picture the electric field more clearly. Representing the electric field by means of these lines helps us in picturing the forces existing between the charged bodies.

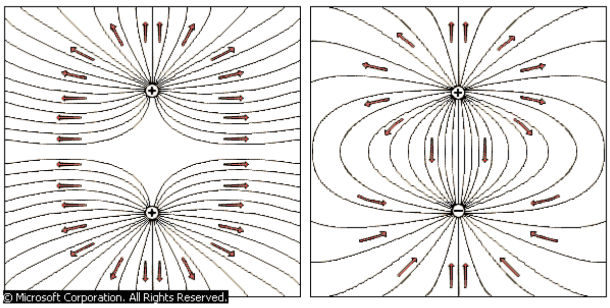


Fig. 27-1. Electric lines of force

Magnetic Lines of Force. Magnetism manifests itself as if it existed in lines emanating from the magnetic materials or current-carrying conductors, these lines being called magnetic lines of force. The stronger the magnet, the more of magnetic lines of force pass through a given space. The magnetic lines taken as a whole constitute a magnetic flux. Just like the lines of force in an electric circuit, magnetic lines of force do not exist in reality. One can imagine magnetic lines as emitted from the north pole and passing through the air to the south pole. However, they do not end on magnetic poles but continue passing from the south to the north pole. The magnetic lines of force are more than merely a means of showing the presence and direction of the magnetic field. They may serve as a unit of measurement since the magnetic field strength is measured by the number of lines of force running through a square centimetre.

Vocabulary:

field – поле
to charge – заряжать
force – сила
intensity – интенсивность; сила, энергия
draw (drew, drawn) – чертить, рисовать
point – точка, пункт

direction – направление
tangent – мат. касательная; тангенс
to coincide – совпадать
vector – мат. вектор
opposite – противоположный
to exist – существовать
obvious – очевидно
to indicate – показывать, указывать
medium – средство, способ; физ. среда
to manifest – ясно показывать, делать очевидным
to emanate – исходить, истекать; происходить
presence – присутствие
to measure – измерять
by means of – при помощи
constitute – составлять

Exercises

27.1 Read the following words:

electrically, coincide, sphere, dielectric, whole, circuit, imagine, measure, strength, through.

27.2 Answer the following questions:

1. Who first used the term "lines of electric intensity"?
2. What did Faraday first represent?
3. Can the lines of force meet?
4. What do we use the lines of force for?
5. How can we represent an electric field?
6. What do the magnetic lines of force constitute?
7. What pole are the magnetic lines emitted from?
8. What do the magnetic lines of force show?

27.3 Translate the following sentences. Pay attention to –ing forms:

1. Charging by induction was discovered by Epinus.
2. On charging an object by induction, we charge it by the influence of

an electrified body at a distance.

3. The lines of force are used for picturing the electric field.

4. In spite of our using the term "lines of force", we remember that they do not really exist.

5. The scientists go on studying the properties of the magnetic flux.

6. There are different ways of producing an electric current.

7. Considering the dielectric medium is the purpose of our work.

8. We could not achieve good results without comparing the two figures.

9. We know of the magnetic lines being emitted from the North pole.

10. On emitting from the North pole, the magnetic lines pass through the air to the South pole.

27.4 Translate the following words and word combinations:

1. meaning, meaningless, to mean, mean, means, by means of, by all means, by no means, meaningly;

2. time, in time, to time, from time to time, in no time, time and again, at times;

3. as long as, as soon as, as well as, as well, as to, as a matter of fact, as far as possible, as far as I know.

28 Conductors and insulators

Fig. 28-1. Conductors

As is well known, to conduct an electric current is the same as to transmit electrons. All substances have some ability to transmit electrons but they differ greatly in the ease with which electrons pass through them. For instance, a copper wire conducts electricity readily, glass seems to conduct so little current that it is hardly measurable. Substances through which currents easily pass are known to be conductors (fig. 28-1). Those substances that strongly resist the flow of current are termed insulators. An insulator is also called a dielectric. It has very few free charges that are able to move under the influence of the electric field fig. 28-2).

There is, however, no sharp distinction between conductors and insulators (dielectrics). Under ordinary conditions there is no perfect conductor and no perfect nonconductor. There is a continuous gradation from good conductors to good dielectrics.

For instance, paper though a poor conductor is by no means a perfect insulator. Indeed, all substances conduct a little electricity — even such materials as porcelain, rubber, paper, and glass, which are considered as good insulators. However, the insulators have so few electrons that can move about freely that, in practice, they allow only a negligible current to flow through them.

Almost all metals are good conductors of electricity but silver is believed to be the best conductor of all. Copper comes next; it is followed by aluminium. Copper is our most commonly used conductor. In addition to its high conductivity, copper is abundant, easily mined and processed.

Some liquids also conduct electric currents. They even prove to be good conductors of electricity. Water with salt conducts electricity well. On the other hand, we know distilled water to have high resistivity.

Most gases conduct current under proper conditions of pressure and temperature. However, they are not as good electrical conductors as metals

As a rule, most of the non-metals are found to transmit only a negligible current; that is why they are considered as insulators. The most common materials used to resist electric flow are: glass, rubber, porcelain, paper, oil, cotton, and silk. Non-ionized clean air is also considered to be a good insulator. It is often used for this purpose in electrical apparatus.

It would be quite wrong to think that conducting materials are the only materials to be used for power transmission. We need both conductors and insulators. Indeed, we cannot do without the copper wire which conducts the electric current, that is, acts as a conductor. However, we have to use an insulator to prevent electrical loss.

In the transmission of power, we generally employ the best conductor available in order that as little power as possible might be lost in heating the transmission line. For other purposes, however, the poorer conductors are often used because they happen to possess other desirable properties. Thus, tungsten is usually the metal to be chosen for the filaments of electric lamps.

Fig. 28-2. Insulators

Vocabulary:

to conduct – проводить
current – поток; ток
to transmit – передавать
ability – способность; возможность
to differ – различаться, отличаться
ease – покой; свобода
to pass – проходить
for instance – например
wire – провод
to seem – казаться
to resist – сопротивляться, противостоять
to flow – течь, протекать
to term – называть
insulator – изолятор
influence – влияние
sharp – острый, резкий; точно, ровно
distinction – отличие
gradation – градация, постепенный переход
poor – бедный; слабый
porcelain – фарфор
rubber – резина; каучук
negligible – незначительный
silver – серебро
abundant – обильный, изобилующий

to employ – нанимать; применять, использовать
to possess – обладать
desirable – желаемый
tungsten – хим. вольфрам
filament – эл. нить накала

Exercises

28.1 Read the following words:

insulator, through, measurable, dielectric, charge, however, though, porcelain, practice, negligible, liquid, ionized, available.

28.2 Answer the following questions:

1. Do all substances transmit electrons?
2. What do we call conductors?
3. What substances are termed insulators?
4. Is there a sharp distinction between conductors and insulators?
5. What metal is considered to be the best conductor of electricity?
6. What materials are used to resist the electric flow?
7. What is the best conductor used in power transmission?
8. What metal is used for the filaments of electric lamps?
9. What insulators do you know?

28.3 Translate the following sentences, paying attention to the functions of the infinitive:

1. To conduct an electric current, we need a source of power.
2. Faraday was the first to represent the electric field by the lines of force.
3. It is possible to detect charges that are not in motion.
4. Substances to resist the flow of current are termed insulators.
5. For a long time the atom was thought to be indivisible.
6. We know this scientist to have worked much on the problems of electricity.
7. Copper is the metal to be used as an electric conductor.

8. Some liquids are found to conduct an electric current.

28.4 Translate the following sentences:

1. Мы знаем, что медная проволока используется как проводник.
2. Считают, что фарфор хороший изолятор.
3. Металлы имеют положительный температурный коэффициент сопротивления.
4. Многие газы проводят ток при определенных условиях температуры и давления
5. Некоторые жидкости проводят электрический ток.
6. Наиболее распространенными проводниками являются металлы.
7. Преимущество медных проводников в том, что они намного дешевле серебряных.

28.5 Form adjectives, using the suffix "-ful":

use, power, success, peace, help, fruit, truth.

29 Lightning

Electrostatic effects are found to be usually characterized by very large potentials or voltages accompanied either by small currents or by currents that last for a very short time. A spark lasts less than one-tenth of a second and sometimes as little a time as a millionth of a second. However, two large spheres separated by a distance of one centimetre have to be charged to a potential difference of 30,000 V, at least, before the electrical intensity is sufficient to force a spark through the air resistance. If the spheres are separated by a distance of, say 40 cm, the potential difference must be nearly a million volts, only then will a spark pass. All know at present, that lightning is a gigantic electric spark between charged clouds or between a charged cloud and the ground (fig.29-1). However, there was a time when lightning was a subject for legends, an insoluble problem that scientists vainly tried to explain. Benjamin Franklin, the great American scientist and progressive statesman, is acknowledged to be the

Fig.29-1. Lightning

pioneer of the theory of atmospheric electricity. In 1752, at Philadelphia, he flew a kite to draw down the lightning from the clouds to the earth and prove it to be electricity. In his famous kite experiment, he demonstrated that atmospheric electricity and static electricity are one and the same thing. And it was he, too, who was the first find the ingenious defense against the destructive action of lightning, — the lightning rod. Franklin was not only an outstanding scientist but also a true friend of the people. He has always been highly appreciated in Russia.

Franklin's achievements were analyzed and approved by Lomonosov who had made his own experiments independently.

The idea of atmospheric electricity greatly interested both Lomonosov and his friend Professor Rihman. Both of them are reported to have made systematic observations and experiments on the subject in question. We know Rihman to have constructed for that purpose the first electrical measuring instrument in the world. However, to carry on investigations of such a kind was more than dangerous in those times.

Vocabulary:

lightning – молния
to accompany – сопровождать; следовать
spark – вспышка
to last – продолжаться
to separate – отделять, разделять
sufficient – достаточный
gigantic – гигантский, громадный
ground – земля
subject – предмет; суть
legend – легенда
insoluble – нерастворимый; неразрешимый
vainly – напрасно
fly (flew, flown) – летать
kite – воздушный шар
ingenious – изобретательный, искусный
defense – защита
destructive – разрушительный
rod – прут, стержень

Exercises

29.1 Read the following international words:

characterize, accompany, sphere, gigantic, theory, electricity, atmospheric, centimeter, distance, destructive, progressive, observations, experiments, observations, demonstrate, construct, instrument.

29.2 Answer the following questions:

1. What are electrostatic effects characterised by?
2. How long does a spark last?
3. What is lightning?
4. What did Franklin demonstrate by his famous experiment?
5. What defense did Franklin find against lightning?
6. Who approved Franklin's achievements?

29.3 Translate the following sentences, paying attention to the infinitive:

1. Coulomb is considered to be the founder of the exact science of electrostatics.
2. Lightning is known to be a great electric spark between charged clouds.
3. Franklin was one of the first scientists to prove that atmospheric electricity and static electricity are one and the same thing.
4. To prove that lightning is atmospheric electricity Franklin carried on his famous kite experiment.
5. To prove that lightning is atmospheric electricity required systematic observations and experiments.
6. We know Franklin to have invented the lightning rod.
7. It is interesting to note that Rihman constructed the first electrical measuring instrument in the world.

29.4 Translate the following sentences, paying attention to the words in bold type:

1. There was **a time** when people knew nothing about electricity.
2. One of the spheres is four **times** as large as the other one.

3. Four **times** four is sixteen.
4. At **times** a spark appeared between the two ends of the wire.
5. The experiment in question was finished in good **time.**
6. **In** those **times** lightning was a subject for legends.
7. What **time** is it? It's high **time** to get up.
8. I think it is **time** to stop the motor.

30 Electric current

When a charge of negative electricity, i. e. of electrons, is put at point on a conductor, that point is momentarily at a potential lower than the potential of the conductor, the electrons flowing along the conductor until all its parts are at the same potential. In case a positive charge is put at a point, the electrons move to that point. The potential at the point being raised, electrons will flow towards that point until all points of the conductor are again at the same potential (fig. 30-1).

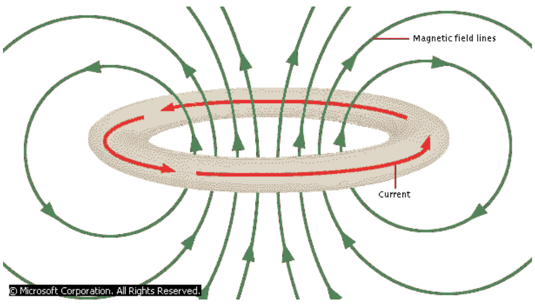


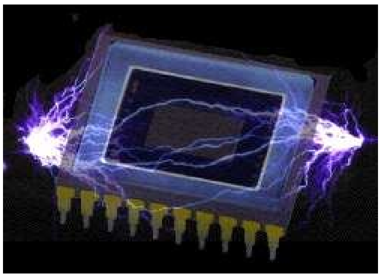
Fig. 30-1.Electric current

If a steady potential difference is maintained by some means between two points in metallic conductor as between the two ends of a copper wire, there will be a steady stream of electrons flowing from the end at low potential to the one at high potential. (Of course, you will remember that the terms "stream" and "flow" are synonyms). This stream (or flow) of moving electrons is one form of electric current. The magnitude of the current is the quantity of electric charge carried by the electrons in a unit of time through any cross-section of the conductor. By a convention adopted before electrons were discovered, we usually say that the electric current in such a conductor flows from points of high potential to those of low potential or in the direction of the potential gradient.

The conductor being a solution, say, of salt in water, the molecules of salt are ionized, both positive and negative ions moving under the influence of the electric field. In this case the sum of the quantities of positive and negative electricity, carried by the ions in a unit of time through any cross-section of the liquid, constitutes the electric current. Such a current is usually accompanied by a chemical action.

An electric current passes through a gas only when the molecules or atoms of the gas are ionized. Here again, both the positive and the negative ions or electrons move under the influence of the electric field, the sum of the quantities of positive and negative electricity carried by the ions in a unit of time through any cross-section of the gas constituting the electric current.

Speaking of electricity in motion, reference should be made to Volta, professor of natural history, at the University of Pavia, Italy. Volta was a clever experimentalist, with a thorough knowledge of all that had been done by others in the field of electricity, a great scientist. In 1800, he constructed the first source of steady, continuous current — the voltaic pile. The voltaic pile was the first battery transforming chemical energy into electrical energy. It is to this invention that we owe the development of modern electrical science and industry.



Electricity Online

Vocabulary:

conductor – проводник

to flow – течь, протекать
towards – к, по направлению к
steady – устойчивый, прочный
to maintain – сохранять; поддерживать
stream – поток
magnitude – величина, размеры
quantity – количество
gradient – уклон; физ. градиент
solution – раствор
influence – влияние
field – поле; сфера
constitute – составлять
reference – ссылка
source – источник
voltaic – гальванический
pile – эл. батарея
owe – быть обязанным

Exercises

30.1 Read the following words:

electric, preceding, steady, high, quantity, molecule, ionize, through, liquid, accompany, chemical, thorough, knowledge, source, owe.

30.2 Answer the following questions:

1. What happens when a charge of negative electricity is put at a point on a conductor?
2. What do you call an electric current?
3. Does an electric current flow from points of low potential to those of high potential?
4. When is a current accompanied by a chemical action?
5. When does an electric current pass through a gas?
6. Who constructed the first battery?
7. When was the voltaic pile constructed?

30.3 Translate the following sentences paying attention to the participle:

1. An electric current passing through a conductor heats that conductor.
2. An electric current passing through a conductor, we generally detect its presence thanks to its various effects.
3. An electric current is the flow of electrons through a metal conductor, these electrons flowing along a wire just like water runs through a pipe.
4. The resistance being very high, the current in the circuit was low.
5. The voltage being increased, the field becomes strong to cause the electrons to produce additional ions by collision.
6. Increasing the cross-section of the wire, we reduce the resistance to current flow.
7. The molecules or atoms of a gas being ionized, an electric current passes through that gas.

30.4 State if the following sentences are true to the fact or false. Correct the false sentences.

1. If a positive charge is put at a point, the electrons move from that point.
2. Copper is a good insulator.
3. Silver is the best conductor of electricity.
4. The current flows from points of low potential to those of high potential.
5. In a salt solution, both positive and negative ions move under the influence of the magnetic field.
6. The voltaic pile was the first generator transforming electric energy into chemical energy.

30.5. Translate the following sentences, paying attention to the functions of the gerund:

1. The magnetic lines of force are not the only means of showing the presence and direction of the magnetic field.
2. The magnetic lines do not end on magnetic poles but continue passing from the South to the North pole.
3. A device which stores electric charges by using the attractions which they exercise on each other is a condenser.
4. There are many ways of using electrical energy.
5. Atomic energy is used in medicine besides its being a source of heat

and power.

6. Connecting the two terminals in a closed circuit leads to a steady flow of current from one terminal to the other.

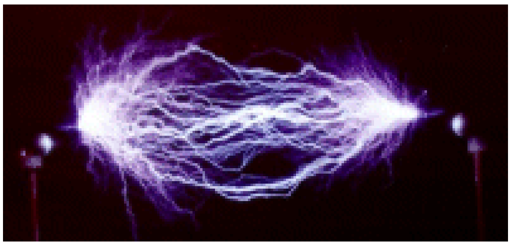
30.6 Translate the following words and phrases:

time, at times, from time to time, in time, in no time, at the same time, time after time, to have a good time, for a short time, to time, out of time, time and again.

30.7 Translate into Russian the following word - combinations:

closed circuit, open circuit, pushbutton, voltaic pile, electric current, potential difference, positive charge, the magnitude of the current, the stream of electrons, chemical action, cross-section, unit of time, salt solution, positive charge.

31 How electricity flows



Any charged object creates around itself an electric field

An electric current is the flow of electrons through a metal conductor, these electrons flowing along a wire much the same as water runs through a pipe.

When connecting the two ends of a conductor to two points at different potentials, for example, such as the terminals of a battery, they say that there is an electric current in the conductor. What actually happens?

The battery causes a potential difference between the ends of the wire and, thus, provides forces that make the electrons move in this wire towards the point of higher potential. It is this electron stream towards the positive electrode that represents the electric current.

However, the positive and negative charges had been named by Benjamin Franklin long before the electron was discovered. As nobody knew then whether the positive charges or the negative ones could freely move in a metal conductor, it was assumed that the current consists of moving positive charges. Since that time, it has become the usual thing to speak of the current as flowing from positive to negative. This direction is generally meant when the term "current" is used.

In other conductors: non-metals, electrolytes, gases the current may be transmitted by negative charges as well as by positive ones. As for metals, they differ greatly in the ease with which electrons can be made to move from atom, to atom.

The magnitude of the current as well as the voltage and resistance may vary from a minute amount to a very large quantity. The electric current passing through a conductor is the amount of electricity (that is, the sum of electron charges) passing through the cross-section of this conductor in a unit of time.

In order to have a steady current, we must have a completed circuit that is also called "closed circuit" and a continuous supply of electric charges. (The terms "closed circuit" and "completed circuit" are synonyms). Another important factor to be taken into consideration is that current strength is equal at all points of a series circuit.

The current starts flowing at the very moment when we close the circuit, for instance, as soon as we turn the light on in our room. If broken anywhere, the electric circuit will immediately stop carrying a current. We can easily observe it many times a day, say, while turning off the light on leaving our room. There is no flow of electrons along a conductor and, therefore, no light as soon as we switch off, that is to say, break the electric circuit.

The local current is 220AC and the connection is made by a two-pin plug

Vocabulary:

charge – заряд
pipe – труба
to cause – вызывать, быть причиной
stream – поток
to represent – представлять, демонстрировать
to assume – принимать во внимание
to mean – значить, означать
ease – покой, свобода
magnitude – величина
quantity – количество
to vary – меняться
strength – сила
series – последовательное соединение

Exercises

31.1 Read the following words:

electricity, charge, electron, minute, through, whether, quantity, previously, though, conventionally, technical, series, circuit, vary, light.

31.2 Answer the following questions:

1. When does a wire carry an electric current?
2. What is an electric current?
3. Does current really flow from positive to negative?
4. How do electrons really move?
5. How does the magnitude of the current vary?

6. When does the current start flowing?
7. When will the circuit stop carrying a current?

31.3 Translate the following sentences:

1. A magnet loses its properties when heated.
2. Potential difference can be measured, if necessary.
3. If broken anywhere, the electric circuit will stop carrying a current.
4. Although a great technical achievement for its time, the electric candle was not an efficient source of power.
5. Almost all substances are known to expand, when heated.
6. The electric current flows provided there is a closed circuit.

31.4 Among the following words find:

a) synonyms:

wire, to begin, flow, the same, completed circuit, provided, to start, for instance, to turn off, minute, to turn on, to switch off, for example, conductor, to switch on, stream, if, the very, closed circuit, small.

b) antonyms:

to charge, minute, the same, negative, direct current, closed circuit, synonym, above, to start, to switch off, light, to switch on, positive, large, to turn off, to discharge, different, to stop, broken circuit, dark, below, alternating current, antonym, to turn on.

31.5 State if the following sentences are true to the fact or false. Correct the false sentences.

1. Electrons are minute positive charges of electricity.
2. An electric current flows from the negative to the positive terminal of the battery.
3. In gases the current may be transmitted both by negative and positive charges.
4. We must have an open circuit in order to have a steady current.
5. When we close the circuit, the current starts flowing.

32 Direct and alternating current

The electric current is simply a flow of electrons that starts, say, from a battery or a generator, passes through resistances, meters, lamps, motors and so on, and finally returns to its starting point. Since such a current moves steadily in one direction, we call it a direct current (fig. 32-1).

The direct current is, of course, useful. It is the kind of current which is always associated with batteries such as those of flashlights, for instance. We know that the electrical system in an automobile and an airplane uses a direct current and so do the telegraph, the telephone, and the tram, and so on. The direct current is also used to meet some of the industrial requirements.

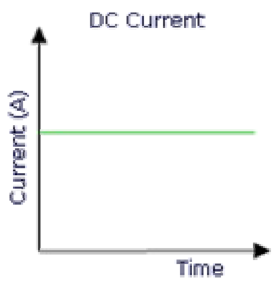
However, at present, most cities with but a few exceptions make use of another kind of electric current for lighting, heating, industrial and other purposes. This current flowing first in one direction and then in another, is named as alternating current (fig. 32-2).

In spite of its usefulness a direct current system has one great disadvantage. As yet, there is no easy, economical way by means of which one can increase or decrease its voltage. The alternating current does not know this disadvantage, alternating voltage increasing or decreasing with little energy loss owing to the transformer.

Using a transformer, it is possible to transform power at low voltage into power at high voltage, power at high voltage being also transformed into power at low voltage.

The alternating current supplies the greatest part of the electric power for industry today. Speaking of motors supplied by the a. c., one should mention asynchronous motors. They are the most useful motors and are less expensive than d. c motors.

Do you know who first widely applied the alternating current in practice? It was Yablochkov, the famous Russian scientist, the inventor of the electric candle. His candle was fed by the a. c. Before him, the a. c. had been used only for laboratory experiments.



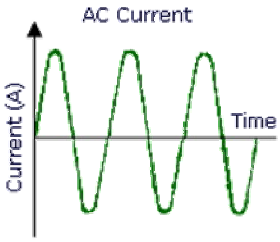


Fig. 32-1. Direct Current

Fig. 32-2. Alternating Current

Vocabulary:

to pass – проходить
to return – возвращаться
steady – устойчивый, постоянный
direct – прямой, эл. однонаправленный
kind – вид, разновидность
requirement – требование
development – развитие
lightning – освещение
purpose – цель
to increase – увеличиваться
loss – потеря
manner – способ
to suit – подходить
alternating – эл. переменный
expensive – дорогой
to apply – применять
candle – свеча
to feed (fed, fed) – питать(ся), кормить

Exercises

32.1 Read the following words:

alternating, electron, through, resistance, steadily, automobile, require, development, purpose, disadvantage, asynchronous.

32.2 Answer the following questions:

1. What is an electric current?
2. Does a direct current change its direction?
3. Where is a direct current used?
4. What kind of current is used for lighting purposes at present?
5. What is the disadvantage of the direct current system?
6. What is the difference between a direct current and an alternating current?
7. Who was the first to apply the alternating current in practice?

32.3 Translate the following sentences:

1. A direct current flows through a conducting circuit in one conduction only.
2. Alternating current flows in cycles.
3. The number of cycles per second is the frequency of an alternating current.
4. There are two frequencies: the standard for Europe is 50 cycles per second while the standard for the USA is 60 cycles per second.
5. The equipment is under test.

6 When necessary a.c. can be changed into d.c.

7 Is it possible to measure the current flowing in an electric circuit?

8 The electric charges produced by friction can be made to flow from one place to another along a wire.

9. It is easy to transform a.c. power from one voltage to another by a transformer.

32.4 Translate the following words and groups of words:

this — thus, then — than, far — for, some — the same, four — for, in order — in order to, from — form, other— each other, few — a few.

32.5 Find in the text English equivalents for the following words and groups of words:

несмотря на, удовлетворять требованиям, при помощи, благодаря, например, в настоящее время, подробно.

33 Meters

Using Ohm's Law and the law of the force of interaction between the magnet and the current, we can make very simple instruments to answer all these questions.

In fact, to measure the current strength and the voltage is not difficult at all, for all you have to do is to connect an ammeter or a voltmeter in the circuit and then you can directly read off the amperes of the former or the volts of the latter.

The amperemeter is known to be the very instrument that is generally used to measure the current flowing in an electric circuit, the electricians having abbreviated the name "amperemeter" to ammeter (fig.33-1). In an ammeter, an armature coil rotates between the poles of a permanent magnet; but the coil restrained by a spring is able to turn but through a small angle. The greater the current in the coil, the greater the force and, therefore, the greater the angle of rotation of the armature. The deflection is measured by means of a pointer attached to the armature, the scale under the pointer reading directly in amperes.

When the currents to be detected and measured are very small one should use a galvanometer. Some very sensitive galvanometers are reported to detect a current as small as 10^{-11} of an ampere, or even smaller.

A voltmeter is an instrument to be used for measuring the potential difference between any two points in a circuit. Its action is similar to that of an ammeter, both of them having armatures that move when an electric current is sent through their coils. The deflection, like that of an ammeter, is proportional to the current flowing through the armature coil. But according to Ohm’s Law, we know volts to equal

amperes times ohms. Hence, the voltage is proportional to the current and the scale may be read directly in volts.

However, in spite of all this similarity between a voltmeter and an ammeter there are also important differences. A voltmeter must have very high resistance because it is allowed to pass only a very tiny current which will not disturb the rest of the circuit. An ammeter, on the other hand, is required to have a low resistance, since all the current must pass through it. In actual use, the ammeter is placed in series with the rest of the circuit, while the voltmeter is placed in parallel with that part of the circuit where the voltage is to be measured.

Fig. 33-1. Ammeter 50 amp

In addition to instruments for measuring current and voltage, there are also devices for measuring electric power and energy.

Vocabulary:

meter – прибор, счетчик
interaction – взаимодействие
to connect – соединять
instrument – прибор, аппарат
armature – тех. арматура; эл. якорь
coil – катушка
to rotate – вращаться, крутиться
pole – физ. полюс
permanent – постоянный
restrain – сдерживать, ограничивать
spring – тех. пружина
angle – угол
to deflect – отклонять(ся)
pointer – указатель

to attach – прикреплять, прикладывать
scale – шкала
sensitive – чувствительный
to detect – обнаруживать, открывать
tiny – очень маленький, крошечный
to disturb – беспокоить, прерывать
device – устройство, прибор

Exercises

33.1 Read the following international words:

electrician, instrument, ammeter, voltmeter, galvanometer, permanent, proportional, rotation.

33.2 Answer the following questions:

1. What is the ammeter used for?
2. What is the voltmeter used for?
3. What is the ohmmeter used for?
4. When do we use galvanometer?
5. What is the difference between a galvanometer and an ammeter?
6. Should the measured circuit be opened when the ammeter is used?
7. In what way should the voltmeter be connected to the circuit?
8. In what way should the ammeter be connected to the circuit?
9. What is the difference between a voltmeter and an ammeter?
10. Can we compare an ammeter with a voltmeter?

33.3 Translate the following sentences paying attention to the infinitive:

1. A galvanometer is a sensitive instrument to detect and measure small electric currents.
2. The resistance of an iron conductor is found to exceed that of a copper one.
3. We know the atmosphere to extend several hundred kilometres above the earth.
4. The current is known to flow through a conductor in case there is a

potential difference between the ends of the conductor.

5. One expects a voltmeter to have very high resistance.

6. Some energy must be expended to make the current flow or to maintain a potential difference at the conductor terminals.

7. To prove Ohm's Law experimentally is not difficult at all.

8. To prove the connection between electricity and magnetism, one must point to the electromagnet.

33.4 Give an English definition for the following terms:

1. ammeter
2. galvanometer
3. voltmeter
4. house service meter

33.5 Find antonyms among the following words:

difficult, insulator, frequently, unnecessary, low, below, little, equal, seldom, necessary, high, easy, above, conductor, unequal, much.

33.6 Read the following abbreviations:

V, W, h. p., km, kg, A, mA, d. c, a. c, gr, in, cm.

33.7 Complete the sentences using the correct variant:

1.. The ammeter is	a) a common meter b) an uncommon device
2. In order to measure the value of current	a) the ohmmeter is used b) the ammeter is used
3.For measuring the potential difference between any two points in a circuit	a) a voltmeter is used b) an ammeter is used c) a galvanometer is used
4. The ammeter should be connected	a) in series b) in parallel

5. To measure small currents
a) a galvanometer is used
b) an ammeter is used
c) a voltmeter

34 Resistance

In everyday conversation the word "resistance" is generally used to mean anything whatever that tends to oppose motion.

If a tram is running at a uniform speed along straight rails, friction tends to reduce the speed of the tram, opposing its motion. Likewise, resistance tends to reduce the flow of the electric current. The power expended in maintaining the current through resistance is transformed into heat. That is why heat develops in a metallic conductor, whenever current flows. The amount of heat developed when the current is flowing through the conductor is the measure of the ohmic resistance of the conductor.

When an electric current flows through a resistance, there is a loss of energy as well as a loss of voltage or electric pressure. Both these losses are directly proportional to the amount of resistance.

The larger the diameter of the wire, the smaller the resistance is and, hence, the more current can flow through it.

As a rule, if the length of a conductor is doubled, the resistance is doubled and if its cross-sectional area is doubled, its resistance is halved. For example, if a copper wire about 4 m long has a resistance of one ohm, the resistance of an eight-meter long wire is two ohms.

The resistance of a conductor depends not only on its diameter and length but also on the kind of substance it is made of and on its temperature.

There are some exceptions to the general rule of increased resistance with increasing temperature. Let us take carbon as an example. Its resistance does increase unless its temperature rises. It differs from metals in this respect. Glass, likewise, when it is hot, conducts current much better than it would, were it cold. Electrolytes, that is to say, solutions through which a current is flowing, also decrease in resistance provided their temperature is increased.

In power transmission one should use as good a conductor as possible so that little power might be lost in heating the conductors of the transmission line.

Vocabulary:

resistance – сопротивление
to tend – иметь тенденцию, иметь склонность
to oppose – сопротивляться, противиться
friction – трение
to reduce – сокращать
to expend – тратить, расходовать
to maintain – сохранять, удерживать
loss – потеря
relationship – взаимоотношение, связь
strength – сила
cross section – поперечное сечение
area – площадь
to depend – зависеть
particular – особенный
doubtless – несомненно
exception – исключение
carbon – хим. углерод; эл. уголь, угольный электрод
glass – стекло
solution – раствор

Exercises

34.1 Read the following words:

resistance, uniform, straight, through, electric, amount, diameter, double, particular, electrolyte.

34.2 Answer the following questions:

1. What does the term "resistance" mean?
2. Does resistance tend to reduce the flow of electric current?
3. What does the resistance of the wire depend on?
4. When do electrons meet more resistance?
5. Does resistance decrease with increasing temperature?
6. Why is it necessary to have good conductors in transmission lines?

34.3 Translate the following sentences:

1. Ohm's Law provided the possibility of determining resistance provided the voltage and current are known.
2. Some materials conduct electricity readily provided light falls on them or their temperature is raised.
3. The addition of heat does not increase the weight of metal, however, the combination with air does increase its weight.
4. If the magnetic circuit consisted of non-magnetic material, the field would be proportional to the current.
5. It is possible to find out the resistance of the conductor at any given temperature, provided the resistance at one temperature is known.
6. The pipe had a small cross-section are and the water flow per second was also small.
7. Unless the cross-section of the wire is decreased, its resistance will be reduced.
8. It is in a transmission line that one should use as good a conductor as possible.

34.4 State to what part of speech the following words belong and translate them:

measure, result, desirable, conductance, influence, generally, good, relationship, important, wire, double, kind, halve, half, only, variation.

34.5 Translate the following words:

1. electric, electrical, electricity, to electrify, electrically, electrification, electrician;
2. to continue, continuous, continuity, continually;
3. chemist, chemical, chemically, chemistry;
4. conduction, conductor, conductivity, conductance, to conduct,

conductive, non-conductor;

5. to magnetize, magnet, magnetically, magnetic, magnetization, to unmagnetize;

6. direct, to direct, direction, director, directly, directive, unidirectional.

34.6 Translate into Russian. Mind no:

1. There is no energy in this machine.
2. No charges move through an open circuit.
3. No material is a perfect conductor.
4. No electric machinery is used without protection.
5. No special material is needed in this case.

34.7 Translate the following sentences:

1. Using tungsten for the filament greatly improved the incandescent lamp.
2. Changing the resistance of a circuit is one of the methods of controlling the flow of current in the circuit.
3. Changing the resistance of the circuit, one may control current flow.
4. The electric current passing through a wire heats that wire.
5. The heat developed will depend upon the amount of current.
6. The heat developed in the electric circuit is of great practical importance for heating and some other purposes.
7. In electric motors, transmission lines, and generators heat is useless and overheating is most undesirable.

35 Two main types of circuit connection

When electrical devices are connected so that the current is not divided at any point, they are said to be connected in series. When two lamp bulbs are connected in series (the wire enters at one side of the socket and leaves it at the other) all the current that flows through the first bulb in one second must also flow through the second bulb in one second. Undoubtedly, under such conditions, the current in every part of a series circuit is the same.

If the current is passed through two lamp bulbs, they will not be so bright as when only one of them is in the circuit, at least, their brightness will be dimmed to a considerable extent. It is because in a series circuit the total resistance equals the sum of all the separate resistances.

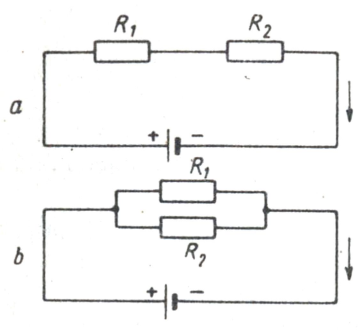
Series circuits are usually automatically controlled so that the current is kept constant regardless of the voltage.

There are, undoubtedly, several advantages in using lamps in series. Namely:

1. A number of low-voltage lamps can be connected to a high-voltage circuit.
2. But one wire is required from lamp to lamp.
3. Most important is the saving in wire material.

The chief disadvantages are that all the lamps must burn at the same time and, in addition, it is dangerous to handle the lamps when the current is on.

A series circuit is by no means the only possible way of circuit connection. In ordinary house lighting, for instance, lamps are connected in parallel, each lamp filament representing an independent path (or branch) from the minus main wire to the plus wire.



Series circuit (a) and parallel circuit (b)

As a matter of fact, in everyday electric work we often deal with circuits where the current branches between two or more paths.

When a circuit is divided in such a way that part of the current goes through one branch and part through another, it is called either a parallel, or a shunt, or a multiple circuit.

In such a case, if we turn on the light in one room, we may see that both bulbs light it brightly. Provided one of the bulbs is unscrewed and removed, the second will continue burning as brightly as before. Doubtless, that is unlike the series circuit.

In parallel circuits the total current is equal to the sum of all the currents that are passing through the branches of that given circuit.

Vocabulary:

series – последовательное соединение
bulb – лампочка
socket – розетка
to leave – покидать, оставлять
to dim – тускнеть, слабеть
considerable – значительно
extent – степень, мера
total – целый, общий
separate – отдельный
to save – экономить
independent – независимый
path – путь, дорожка, тропинка
branch – ветвь
shunt – эл. шунт
multiple – многократный, многочисленный
to screw – привинчивать, завинчивать
to remove – удалять

Exercises

35.1 Read the following words:

series, undoubtedly, bright, equal, automatically, disadvantage, doubtless, multiple, unscrew, through, size, bulb, resistance, filament, undoubtedly.

35.2 Answer the following questions:

1. How many circuit connections are discussed in the text?
2. How are the series circuits controlled?
3. Why is the current kept constant in a series circuit?
4. What are the advantages of using lamps in series?
5. What is the difference between a series circuit and a parallel circuit?
6. What is the total current equal to in a parallel circuit?

35.3 Translate the following sentences, paying attention to the words in bold type:

a) 1. Solutions through which a current is flowing, decrease in resistance **provided** their temperature is increased.
2. These satellites are **provided** with the most modern equipment.
3. Ohm's Law **provided** the possibility of determining the resistance **provided** the voltage and the amount of current are known.
4. The first nuclear power plant **provided** the further development of peaceful applications of nuclear power.
5. An electric current will flow **provided** there is a completed circuit.

b) 1. All **matter** is composed of molecules.
2. **As a matter of fact** a fuse made of lead breaks the circuit when overloaded.
3. A wire and an electric cell **form** an electric circuit.
4. The stream of moving electrons is one **form** of an electric current.
5. The scientists of our country constructed a **number** of satellites.
6. The resistance in the coil depends upon the **number** of turns in it.
7. The equipment under consideration will require **but** one worker to handle it.
8. We know, at present, that lightning is an electric spark **but** there was a time when it was a problem that scientists were unable to solve.
9. **But for** the fuse a short circuit might cause fire.
10. Let us **picture** 2 lamps connected in shunt.
11. Do you see any **picture** on this page?
12. Lomonosov was **the only** scientist who wrote his articles in the Russian language.
13. **Only** one lamp is burning here.

35.4 From the words given below form adjectives using the following suffixes:

a) -able

to change, to consider, to suit, to move, to compare, to control, to represent, to divide, to work;

b) -ous

danger, advantage, to vary, to continue;

c) -less

doubt, form, wire, regard, use, help, hope;

d) -al

industry, centre, culture, form, nation, mechanics.

36 Electromotive force

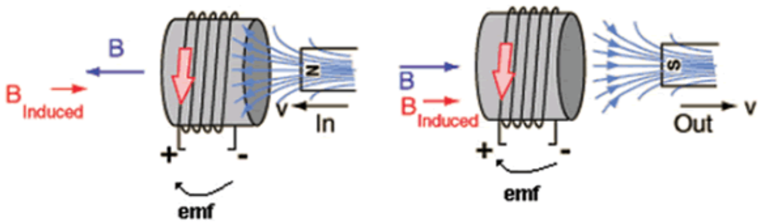


Fig. 36-1. Electromotive force

We have already seen that the flow of current in a metallic conductor is always accompanied by the development of heat. We also know that energy must be expended to make the current flow or, in other words, to maintain potential difference at the terminals of the conductor.

It is obvious that a current will not flow in a circuit made up entirely of metallic wires.

There must be some driving force to cause the electrons to move through the metal conductor. This driving force tending to produce the motion of electrons through a circuit is called an electromotive force or an e. m. f., for short. It is the e. m. f. that moves electrical charges from one point in the circuit to another (fig. 36-1).

It is quite clear that the greater the electromotive force, the greater the pressure on the electrons moving through the conductor. However, although they call it a force, it is not a force at all, as that term is understood in mechanics.

A battery or other source of an electromotive force is simply a device that produces a potential difference necessary for causing the electric current (electrons) to flow along a conductor. The current is known to flow through a conductor in case there is a difference of potential between the ends of the conductor, for it is then that an electromotive force is present.

One should distinguish between an electromotive force and a potential difference. A generator or a battery is a source of an electromotive force, whereas the voltage across a resistance in which a current is flowing is a potential difference or a voltage drop. In general, the e. m. f. of a battery or generator cannot be measured exactly at its terminals, since these devices have an internal voltage drop when the circuit is completed. If an e. m. f. is applied to a path which allows the electrons to pass, they will move toward the point of higher potential, and then a current is said to flow in the circuit. It is necessary to take into consideration that the direction of movement of the electrons is opposite to the conventional direction for current in a conductor; that direction is considered to be away from the point of higher potential.

Vocabulary:

electromotive – электродвижущий
force – сила
to expend – тратить, использовать
to flow – течь, проходить
to maintain – сохранять, удерживать
driving force – движущая сила
to cause – вызывать, быть причиной
motion – движение
pressure – давление

to distinguish – различать, отличать
drop – падение, понижение
internal – внутренний
to apply – применять, использовать
to allow – позволять, разрешать
opposite – противоположный
conventional – условный; тех. стандартный

Exercises

36.1 Read the following words:

electromotive, accompany, development, entirely, cause, electron, although, quantity, electricity, mechanical, source, measurable, experimentator.

36.2 Answer the following questions:

1. What is the flow of current accompanied by?
2. What causes the electrons to move through a conductor?
3. Is energy expended to make the current flow?
4. What do we call an e. m. f.?
5. Is an e. m. f. really a force?
6. What is a battery?
7. When does the current flow through a conductor?
8. What is the difference between an e. m. f. and a potential difference?

36.3 Translate the following sentences:

1. It is said that some people don't distinguish between an e. m. f. and a potential difference.
2. It is necessary to remember that an electric current flows in the completed circuit under the influence of an e.m.f.
3. It is known that a generator or a battery can be a source of an e. m. f.
4. One can say that an e. m. f. moves electrical charges from one point to another.
5. One should remember that the voltmeter is the instrument used for

measuring an e. m. f.
6. The lines of force are thought to leave the north pole of the magnet and enter the south pole.
7. A generator is known to be a source of an e. m. f.
8. Electrons were found to move in some definite direction under the influence of an e. m. f.

36.4 Translate the following sentences, paying attention to the words in bold type:

1. To measure the resistance in the circuit **one** should use special instruments.
2. The electric generator is **one** of the most useful sources of an e. m. f.
3. If the wire is a large **one** and the current is a small **one**, **one** should use a thermometer to detect the developed heat.
4. **One** must remember that **one** form of energy can be turned into another **one**.
5. **One** can imagine magnetic lines as emitted from the north pole and passing through the air to the south pole.

36.5 Find in the article the English equivalents for the following words:

предполагается, очевидно, необходимо, было установлено, известно, трудно, возможно.

36.6 ***Translate the following words and define the meaning of their prefixes:***

disproportional, indifferent, impossible, to reheat, preheat, overload, megohm, to miscalculate, reaction, milliampere, to misunderstand, irregular, dissimilar, supercritical, undoubtedly, impractical, disproportional, misdirection, immeasurable.

36.7 Find among the following words:

a) antonyms

similar, action, conductor, minus, closed circuit, reaction, possible, dissimilar, insulator, open circuit, impossible, plus;

b) synonyms

speed, through, stream, obviously, motion, across, device, movement, rate, flow, instrument, evidently.

37 Incandescent lamp

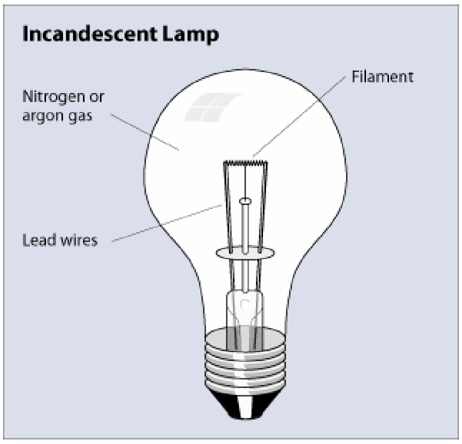


Fig. 37-1. Incandescent lamp

When the conductor of an electric current is so hot that it radiates light rays, it is said to be incandescent. Conductors used for making lamp filaments, when heated, soon become so hot that they radiate a white light. In other words, the light is radiated by a metal filament heated to incandescence by the electric current (fig. 37-1).The percentage of luminous radiation from a hot body is low but it rapidly increases with the increase in temperature of the radiating body.

The filament must be placed in an air-tight place for it will burn out unless oxygen is removed.

Incandescent lamps of older types had carbon filaments prepared in various ways. To make a suitable lamp filament was an extremely difficult thing. Lodygin, for instance, had to experiment several years before he was able to make the first incandescent lamp burn successfully. By the way, he was the first to use tungsten for filament. Some idea of the work this problem involved may be gathered from the fact that Edison had tried 6,000 different materials before he hit upon the carbonized filament.

As the efficiency of an incandescent lamp greatly depends upon the temperature its filament can be heated to, tungsten is now mostly used for lamp filaments. Its melting point reaches about 3,300° C. The energy to be expended per candle power is less than half that used by carbon lamps of the same type. Generally speaking, tungsten and tantalum are the very metals that are used for lamp filament production, at present. The resistance of these metals is considerably less than that of carbon. The light radiated is whiter and, as stated earlier, it requires less current than with the carbon filaments.

The modern tungsten lamp filament is a coil whose ends are fastened to the ends of supports connected with leading wires.

Two great inventors played a prominent part in the development of the incandescent lamp. Their names are Lodygin and Edison. Lodygin was not only the inventor of the lamp under consideration, but also the first scientist to use it for lighting purposes. When Lodygin's lamp appeared first and replaced the arc lamp, it attracted Edison's attention. For several years the American inventor worked hard at its improvement. At last, in 1879, he created an improved incandescent lamp suited for practical purposes and finally solved the problem of cheap electric lighting on a large scale.

Vocabulary:

ray – луч
filament – нить накала
incandescent – раскаленный, накаленный добела
candescence – накаливание добела
luminous – светящийся
rapidly – быстро
oxygen – кислород
to remove – удалять
suitable – подходящий
melting point – точка плавления
tungsten – хим. вольфрам
tantalum – хим. тантал
to fasten – закреплять, прикреплять
prominent – выдающийся, известный
arc – дуга
to attract – привлекать
to solve – решать

Exercises

37.1 Read the following words:

incandescent, behind, candle, light, white, percentage, luminous, air-tight, successfully, development.

37.2 Answer the following questions:

1. When does a conductor radiate light rays?
2. Why must the lamp filament be placed in an air-tight place?
3. What filaments were used in incandescent lamps of older type?
4. Who was the first to use tungsten filaments in incandescent lamps?
5. What does the efficiency of an incandescent lamp depend upon?
6. How many inventors worked at the incandescent lamp development?
7. Who else worked at the incandescent lamp improvement?

37.3 Translate the following sentences and define the functions of the words in bold type:

1. The water rheostat is often used as an emergency device for controlling large currents for a certain period of time, **for** water is found almost everywhere.
2. Lodygin received a patent **for** his invention in America.
3. Edison worked, at the improvement of the incandescent lamp for a long time **for** this problem interested him greatly.
4. The incandescent lamps are used **for** lighting purposes.
5. **But for** tungsten the filament would burn out in no time.
6. As **for** tungsten it is still considered to be the very metal used for filament production.

37.4 Translate the following sentences:

1. The relative motion of a conductor or of a magnetic flux determines the e. m. f. induced.
2. If the magnetic flux is cut in the manner described, an e. m. f. will be induced.
3. When a tungsten filament lamp is burning, the light radiated is white.
4. The tungsten filament placed in an air-tight bulb and heated by an electric current radiates light.
5. The incandescent lamp improved by Edison suited for practical purposes.
6. The problem the scientist solved was extremely difficult.

7. The laboratories our students work in are provided with the best production equipment.
8. Lodygin constructed an incandescent lamp which could burn for two hours.
9. All the necessary data we found in the magazine are of great practical importance.
10. The facts you told me about are connected with the history of electrical engineering.

37.5 Translate the following adjectivised nouns used as attributes:

carbon filament, carbon filament lamp, carbon filament lamp development, metal filament lamp, lamp filament production, incandescent lamp filament production, lamp filament production problem, power plant generator work, electric energy generation plan, electrification program development.

37.6 Find in the article attributes for the following nouns and translate the word combinations formed:

force, difference, wire, direction, energy, assumption.

38 Chemical and electrical energy

The invention of the electric cell opened the way for the use of a continuously flowing current. The electric current from a cell was found to last relatively long. Discharge from a battery or a dry cell results in a steady flow of an electric current.

As one should know, the electric cell is the very device to convert chemical energy into electric energy. Part of this energy being changed into heat, not all the chemical energy of the cell or battery is transformed into electric energy. At any rate, the sum total of the chemical energy is computed to equal the sum total of all the other forms of energy into which it is converted. The principle of the conservation and transformation of energy also holds with regard to the electric cell.

Chemical reaction within the cell tends to keep the two battery terminals charged, one with a positive charge and the other with a negative charge. Connecting the two terminals in a closed circuit leads to a steady flow of electric current from one terminal to the other. What this flow of current was and how it could flow along a wire has long interested electrical scientists. At first, they thought it to be a kind of liquid that really flowed along the wire and back to the battery.

Only the modern theory of the composition of matter could give, at last, the real and the only possible explanation of the movement of the electric current. The flow of electrons from the zinc plate to the copper plate in the external circuit was found to represent electrical energy. This energy comes from the zinc that is dissolved in the electrolyte.

The crowded electrons on the zinc plate of the cell tend to move towards the copper one because of the electrical pressure created. To connect the two plates with a copper wire means to form a path for electron flow. In other words, the copper wire that connects the two plates forms a very easy path for the movement of electrons. It is considered to be a good conductor of electricity. Electrons moving through a wire, electrical energy is generated. Moving electrons can do work. They can produce heat and light and can make motors run.

We know that the wire and the electric cell form an electric circuit. If the wire is disconnected or broken at any point, the current of electricity will not flow. In such cases the circuit is said to be open.

If there is no electrical connection between the zinc and the copper but a little zinc will dissolve.

When the wire is connected in such a manner that the current can flow, the circuit is said to be closed.

Vocabulary:

cell – эл. элемент
continuous – непрерывный
charge – заряд
to last – длиться, продолжаться
steady – стабильный, постоянный

to convert – превращать, конвертировать
plate – пластинка; эл. анод
conservation – сохранение
transformation – превращение
terminal – эл. клемма; ввод или вывод
to flow – течь, протекать
external – внешний, наружный
to generate – вырабатывать

Exercises

38.1 Read the following international words:

chemical, electrical, convert, theory, electrolyte, zinc, transformation, terminal, generation, battery, manner.

38.2 Answer the following questions:

1. What device converts chemical energy into electrical energy?
2. Is all chemical energy of a battery transformed into electrical energy?
3. What does a chemical reaction within the cell tend to do?
4. What takes place within the cell?
5. Why do the electrons on the zinc plate move towards the copper plate?
6. What can moving electrons do?
7. Will a current flow if the wire is broken?
8. What do you call a completed circuit?

38.3 Translate the following sentences paying attention to the infinitive:

1. We know the storage battery to be made of chemicals to generate an electrical current at the expense of chemical energy.
2. When the currents to be detected and measured are very small, one should use a galvanometer.
3. A galvanometer is a sensitive instrument used to detect and measure small electrical currents.
4. Capacity is the property of a conductor determining the quantity of electric charges to be put upon it in order to bring its potential to a given

number of volts.

5. The process of conducting an electric current through a liquid to produce chemical changes in that liquid is known as electrolysis.

6. Lodygin was the first to use an incandescent lamp for lighting purposes.

7. We know the electric cell to be a device used for converting chemical energy into electrical energy.

8. Tungsten which has been discovered in 1783 seemed to have the highest melting point.

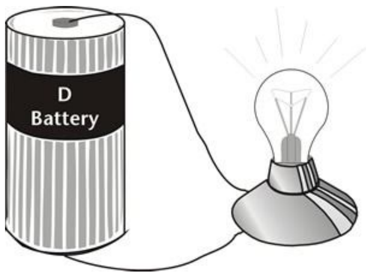
9. To measure the current is quite necessary for our experiment.

38.4 Translate the following words and define their part of speech:

1. chemical, chemistry, chemically, chemist;
2. relate, relation, relative, relatively, relativity;
3. invention, inventor, invent, inventive;
4. position, positive, positively, opposition, oppose;
5. producer, produce, production, productive, productivity, productively, unproductive, product;
6. connect, disconnect, connection, connective, connected, unconnected;
7. chargeable, discharge, recharge, charge, charger.

39 Batteries

Primary and Secondary Cells. The term "battery" applies strictly to an assembly of several cells connected either in series or in parallel but the terms "cell" and "battery" are frequently misused, that is, used interchangeably.



Batteries produce electricity

Each cell is provided with two plates of conducting material connected together and immersed in an electrolyte. When both the plates of differing conducting material are immersed in an electrolyte, there is a difference of potential between each of these plates and the electrolyte.

If the plates are connected together through an external circuit, a current will result and chemical reactions will occur in the cell.

Primary cells are electrochemical devices designed to develop an electrical potential and convert chemical energy into electrical energy. The parts of a primary battery are consumed as it furnishes electrical energy, therefore, it is either destroyed, at last, or some parts of it are renewed.

Secondary cells, or as they are more commonly called storage cells, are made use of both to convert chemical energy into electrical energy and to reconvert the latter into chemical energy.

After a definite amount of electricity has been delivered by the discharge of the battery, the active material of the plates can be restored to its original or charged condition by passing an electric current through the battery in a reverse direction.

The process is called electrolysis provided the electric current passes through a liquid so as to produce chemical changes in that liquid. The laws of electrolysis were first stated by Faraday who made fundamental investigations in the field of electrolysis.

The cell, or battery, has played an important part in the development of science and engineering. As batteries perform innumerable useful services, doubtless, many of our modern achievements would have been quite impossible but for the battery.

Vocabulary:

assembly – тех. монтаж, сборка
to immerse – погружать
to occur – случаться, происходить
to consume – потреблять, расходовать
to destroy – разрушать

storage – хранение, накапливание
to deliver – доставлять
discharge – эл. разряд
to restore – восстанавливать
reverse – обратный
electrolysis – электролиз
investigation – исследование
field – область, сфера; поле

Exercises

39.1 Read the following international words:

electrolyte, electrochemical, electrolysis, characteristics, potential, result, reaction, battery, fundamental, process, engineering, origin.

39.2 Answer the following questions:

1. What does the term "battery" really mean?
2. What is the cell provided with?
3. When will chemical reactions occur in the cell?
4. What are primary cells?
5. What are storage cells used for?
6. How can the active material of the plates be restored to its original condition?
7. Who stated the laws of electrolysis?

39.3 State if the following sentences are true to the fact or false. Correct the false sentences.

1. A cell consists of three plates of insulating material connected together.
2. Primary cells are designed to convert chemical energy into mechanical energy.
3. Secondary cells convert chemical energy into electrical energy and reconvert it into chemical energy.
4. Volta made fundamental investigations in the field of electrolysis.
5. Wet cells contain liquids.

6. Dry cells do not contain any liquid, they are really dry.

39.4 Give all the derivatives from the following words and translate them:

to apply, to use, to change, to differ, to direct, to convert, to charge.

39.5 Form adjectives from the following nouns using the suffix:

a) "-ful": use, power, doubt, help, success, fruit;
b) "-less": doubt, weight, end, friction, use, ground.

39.6 Read and translate the following pairs of words:

to use — use, to subject — subject, to present — present, to object — object, to increase — increase, to export —export, to transport — transport, to perfect — perfect.

39.7 Translate the following words and define their part of speech:

strictly, condition, assembly, commonly, primary, external, destroy, moisture, changeably, direction, fundamental, electrostatic, consideration, development, impossible, doubtless, portability, action.

40 The fuel cell

Fig.40-1. Fuel cell

A fuel cell is a device for generating electricity (fig.40-1).

To generate electricity from a fuel such as coal or oil, that coal or oil should first be burned. It is the energy of burning that heats water to steam. Steam, in its turn, is used to rotate a turbine. The turbine operates a generator which produces an electric current. In other words, we convert the chemical energy of the fuel into heat energy, the latter being converted into mechanical and then electrical energy.

Chemical energy can also be converted into electrical energy directly, without going through heat. To do so we must make use of an electric cell. Such a cell consists of one or more solutions of chemicals into which two metal rods, called electrodes, should be immersed. A particular chemical reaction goes on at each electrode and electrons are either released or absorbed. The electron pressure at one electrode is higher than that at the other, so that unless the two electrodes are connected by a wire, electrons will not flow through that wire from one electrode to the other.

In some cases, if an electric current is forced back through a cell after that cell has been exhausted, the chemical reactions within it are made to run in reverse. Thus, the cell can then store chemical energy and be used to produce an electric current again. The storage battery in an automobile is an example of such a reversible battery.

A little chemical energy is wasted in a cell, since it is there that chemical energy is converted into electricity in a single process. Certainly, the chemicals used in cells are all rather expensive. Zinc does go into the making of a flashlight battery, whereas lead into the making of an automobile storage battery.

The fuel cell must be a device in which the properties of fuel and those of an electric cell are combined. It is the cell in which cheap fuels are used instead of expensive metals in the chemical reactions.

The chemical energy of these fuels is turned into electrical energy in a single process with less waste than in the usual double process.

A great advantage of the fuel cell is that it continuously provides uninterrupted electrical energy until the external fuel sources are exhausted.

Of particular importance is its extremely high efficiency if compared with other methods of power generation and its economical fuel consumption. In effect, the fuel cell is a battery that does not wear out rapidly, does not need recharging, and weighs much less. It is noiseless and can withstand great overloads. An example of a fuel cell is the hydrogen-oxygen fuel cell containing two electrodes and an electrolyte.

Fuel-cell-airplane

Vocabulary:

device – устройство
to rotate – вращаться
to convert – превращаться; конвертировать
solution – раствор
rod – прут; стержень; брус
to release – освобождать; выпускать
to exhaust – истощать, исчерпывать
storage – хранение
to waste – тратить
lead – свинец
external – внешний
consumption – потребление
overload – перегрузка

Exercises

40.1 Read the following words:

chemical, course, double, quantity, immerse, electron, exhaust, reversible, automobile, advantage, oxygen, hydrogen.

40.2 Answer the following questions:

1. What do you call a fuel cell?
2. What is steam used for?

3. Can chemical energy be converted directly into heat energy?
4. What do we use an electric cell for?
5. What does an electric cell consist of?
6. Where is the storage battery used?
7. What is the difference between a fuel cell and an electric cell?
8. What are the advantages of a fuel cell?

40.3 Translate the following sentences:

a) 1. It is in space flights that the fuel cells have been proved reliable in operation.

2. Both types of batteries do generate current in cells through a chemical reaction.
3. It is the extremely high efficiency of the fuel cell that attracts the scientists' attention.
4. It is the fuel cell that is the promising power source for the future.

Lead does go into the making of an automobile storage battery.

b) 1. If a few of the atoms of a body had an electron removed, the body would have a small charge.

2. The force of the earth's gravitation will decrease provided the distance from the earth increases.
3. Were the plates connected together through an external circuit, a current would result and chemical reactions would occur in the cell.
4. As the charge of the electron is negative and that of the proton is positive, it might be thought that the proton would attract the lighter electron and draw it into the nucleus. This would happen unless the electron were revolving around the nucleus.

40.4 State if the following sentences are true to the fact or false. Correct the false sentences.

1. A fuel cell is a device used for measuring temperature.
2. We can convert the chemical energy of the fuel into electric energy.
3. Expensive metals instead of cheap fuels are used in a fuel cell.
4. A great advantage of the fuel cell is that it continuously provides chemical energy.
5. A fuel cell needs recharging and weighs very much.

41 Self –induction

We know that when an electric current flows in a circuit, a magnetic field is produced by it. The direction of this field is correlated with that of the current.

Thus, the current in a conductor always produces magnetic field surrounding or linking with the conductor. This current changing, the magnetic field will change as well; and whenever there is a change in the magnetic field surrounding a conductor, an e. m. f. is induced in the conductor. This e. m. f. is called a se1f-induced e. m. f. because it is induced in the current-carrying conductor. The relationship between the current and the induced e. m. f. is a fundamental characteristic of an electric circuit. It was examined by the outstanding Russian scientist Lenz. He discovered the following: when the current in a circuit increases, the flux linking with the circuit also increases; this flux induces an e. m. f. in the conductor in such a direction as to oppose the magnetic flux increase. The current decreasing, an e. m. f. is induced in the direction which coincides with that of the current, thus, opposing the decrease of current. Lenz stated that the self-induced e. m. f. impedes any current change and tends to support the former current value. The above is known as Lenz's Law (fig. 41-1).

An electric circuit in which an appreciable e. m. f. is induced, while the current is changing, is called an inductive circuit, and we say that the circuit has self-inductance. In other words, the inducing of an e. m. f. in a circuit by a varying current in that very circuit is called self-induction.

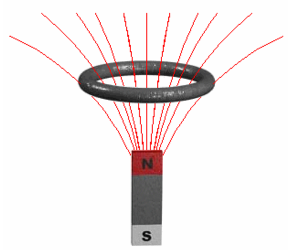


Fig. 41-1. Lenz's Law

Remember that the induced e. m. f. is proportional to the rate the lines of force are cut at. Therefore, if the coil has many turns and produces a strong magnetic field, and if the current is stopped very quickly, the rapid collapse of the field will greatly increase the rate at which the lines of force are cut. But the cutting of the lines of force occurs only during the very short time that the magnetic field is collapsing, so only then is the extra current induced.

Vocabulary:

to exceed – увеличивать
distribution – распределение
property – свойство
to induce – эл. индуктировать
to correlate – устанавливать соотношение
to surround – окружать
to link – соединять, связывать
to coincide – совпадать
to impede – препятствовать, мешать, задерживать
appreciable – заметный, ощутимый; поддающийся оценке
rate – скорость; норма
to cut – резать, рассекать
collapse – рушиться, сильно слабеть

Exercises

41.1 Read the following words:

comparatively, exceed, require, characteristic, flux, impede, value, appreciable, collapse.

41.2 Answer the following questions:

1. Why does most of the world use a. c?
2. What property of an electric circuit was discovered by Faraday?
3. Is a magnetic field produced when an electric current flows in a circuit?
4. When is an e. m. f. induced in a conductor?
5. What was discovered by Lenz?

6. What is an induced e. m. f. proportional to?

41.3 Translate the following sentences and define the functions of the participle:

1. A simple example of self-inductance will be considered here.
2. Lenz stated that the self-induced electromotive force impeded any change of current, the above being known as Lenz's Law.
3. A conductor moving through a field will cut the lines of force at a rate that is influenced by several factors.
4. Speaking of self-induction, one should mention Faraday's discovery.
5. The pole of a magnet being moved towards one face of the coil, the current induced in the coil produces a magnetic field.
6. The north pole of a magnet being moved closer to a coil, the induced current causes a field opposing the motion.
7. Having determined the number of amperes and volts, one can find the resistance of the coil.
8. The relative motion of both the flux and the conductor determines the e. m. f. induced.
9. Working at his new device, the inventor made a number of improvements, the latter resulting from his own experiments.
10. The lines of force being cut by the wire, an e. m. f. is induced in that wire.

41.4 Find antonyms in the article for the following words:

high voltage, insulator, decrease, the latter, large, long, to cover, often, dangerous, unnecessary, action.

41.5 Translate and compare the following groups of words:

date —data; minute (n) — minute (a); both— both... and; fact — in fact; this — thus; other — each other; that — so that; later — the latter — letter; some — the same; through— though; to put — to put down; to carry — to carry on; ten times —much time; so — or so; to give — to give up; in order — in order to.

41.6 Translate the following sentences:

1. When placed in a magnetic field, the molecules of steel do not readily

turn around in the direction of the lines of force.

2. If properly designed, the meter should give correct readings.
3. We should rub steel always in the same direction when magnetizing it.
4. As previously mentioned, an electric current produces a magnetic field.
5. Electrons generate electrical energy, while moving along a wire.
6. Although quite young, Faraday had to work as a bookbinder's apprentice.
7. Power can be generated wherever suitable and used wherever required.

42 Mutual induction

Changes of current in one circuit induce a current in another circuit. We have seen that, when the field of an electromagnet collapses, an electromotive force is induced by the lines of force cutting across the magnet’s winding: that is to say, an e.m.f. is induced in the coil by the lines of force of its changing magnetic field, this effect being called self-induction.

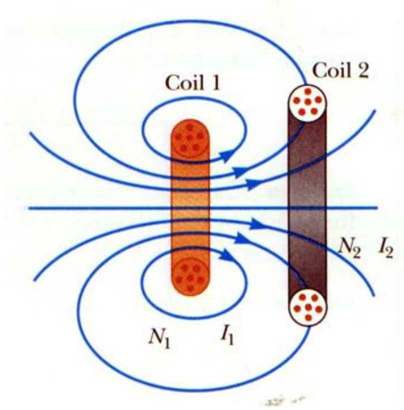


Fig. 42-1. Mutual inductance

Now let us suppose that near-by there is another coil which is connected to another circuit. The lines of force from the first coil will also cut the wire of the second coil when the magnetic field collapses or is built up (fig. 42-1).

Thus, we should expect that an e. m. f. is induced in this coil too, and such is really the case.

Let us call the first coil — the primary and the second coil — the secondary. Suppose that we connect the ends of the secondary to a lamp. Now we place this coil within, say, 30 cm or so of the primary. If a direct current is flowing through the first coil, no effect will be observed as long as the current is steady. However, the current being suddenly shut off, the lamp attached to the second coil flashes more or less brightly. Moving the coils sufficiently close together, we can also make the lamp flash when the switch is suddenly turned off.

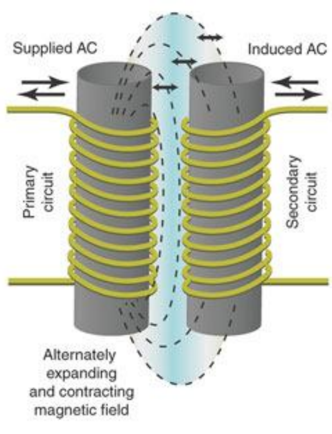
Here we see that the lines of force from the first coil induce a current in the circuit of the second coil, this being another kind of induction. The effect involving both coils and being a mutual one, we call it mutual induction.

We know that the effect of self-induction was continuous in an a. c. circuit. So, let us connect our primary coil directly to the 120-volt, 50-cycle a.c. circuit and then gradually bring the secondary coil nearer.

We find that the lamp burns continuously. The reason is that the rise, fall and reversal of the alternating current cause the lines of force of the primary to be rising, falling and reversing across the secondary. The lines of force that cut the secondary coil wire induce an e. m. f. in it, causing a current in the secondary circuit.

The primary and the secondary coils may be considered as linked by the moving force lines of the changing magnetic field. The total number of lines of force passing through a coil or any other area is generally called — m a g n e t i c flux.

The voltage induced in the secondary coil depends upon the rate, the lines of force are cut at, when the current in the primary coil changes or upon the rate of the magnetic flux change. Therefore, the greater the rate of change of the magnetic flux reaching the secondary coil and passing through it, the greater the induced e. m. f. and current in the secondary circuit.



Mutual inductance

Vocabulary:

mutual – взаимный
primary – первичный
secondary – вторичный
steady – устойчивый, прочный
winding – обмотка
coil – катушка
to flash – сверкать, вспыхивать
to shut off – выключать, изолировать
to involve – включать
gradually – постепенно

Exercises

42.1 Read the following words:

winding, steady, brightly, mutual, cause, through, flux, induce, however, reverse.

42.2 Answer the following questions:

1. What kinds of induction do you know?
2. When do the lines of force from the first coil cut the wire of the second coil?
3. Can you give us an example of mutual induction?
4. When is a current caused in the secondary circuit?
5. What do we call a magnetic flux?
6. Are the primary and the secondary coils really linked by the force

lines?
7. What does the voltage in the secondary coil depend upon?
8. What is the difference between self-induction and mutual induction?

42.3 Translate the following sentences:

1. In spite of our calling an e. m. f. a "force", it is not a force at all, as that term is understood in mechanics.
2. Plants are useful sources of energy thanks to their storing the sun's radiation in chemical form.
3. One cannot use this new instrument without its being regulated.
4. We heard of the new device having been put into operation.
5. Everyone knows of Lomonosov's being a great Russian scientist.

42.4 Translate the following word combinations:

1. соединяющая проволока, соединенная проволока, соединяя проволоку, соединив проволоку;
2. наводимый ток, наведя ток, наведенный ток.

42.5 Explain the meaning of the prefixes in the following words:

to overheat, to preheat, to reheat, to mislead, to discover, to rediscover, to underestimate, unreliable, imperfect, irregular, ineffective, illegal, to misunderstand, unnecessary, discharge, recharge.

42.6 Find in the article adjectives for the following nouns:

circuit, flux, coil, induction, current, force.

43 Electric current generation

There are at least four principal methods available for generating electric currents: 1. chemical reaction; 2. thermal or heat action; 3. light action, and last but not least, 4. magnetic action.

Batteries can generate electricity by means of chemical reactions. To produce a current by chemical reaction, an alkali or an acid is made to react with a metal. The device to be used is called a voltaic or an electric cell, a group of two

or more cells connected together forming a battery. The voltaic cell is so named after Volta, its inventor, who was the first to show that electricity could be generated owing to chemical reactions.

Thermocouple

Heat is certain to produce current when applied to two unlike metals soldered together in two points. The apparatus used is called a thermoelectric couple or thermocouple, for short. The word "couple" used in this term should mean that two unlike metals or metals and alloys, say, such as cooper and constantan are joined together so that they can be properly heated in the point of the joint.

The reason the thermocouple generates current is due to the fact that the heat tears the electrons off of the negatively charged metal at the point of joint just as the electric cell chemical reaction is expected to tear the electrons off of the zinc electrode. It is these electrons that constitute the current flowing through the circuit.

There are semiconductor thermo elements which without any machinery convert thermal energy into electric energy as efficiently as small steam installations do.

Falling on a special kind of cell, a light beam can generate an electric current. The appliance using that phenomenon to produce electricity is called a photoelectric cell. Photoelectric cells appear to be used in a great number of common devices. One can't help mentioning lasers, too, since it has been found that laser powerful beams can be turned into electricity with a very high efficiency.

To generate a current by magnetic action, a wire is made to pass through a magnetic field, the latter being set up either by a permanent magnet or an electromagnet. In the case of the wire cutting through the magnetic field of a permanent magnet, the appliance is called a magneto-electric machine or simply “magneto”. The wire cutting through the magnetic field of an electromagnet, the apparatus is said to be a dynamo electric machine or a dynamo, for short. Generally speaking, there are several ways by means of which electric currents can be generated by magnetic action, all of them being based on the same principle, namely, on cutting magnetic force lines with a conductor.

Vocabulary:

to generate – вырабатывать, генерировать
reversible – тех. реверсивный
by means – посредством, при помощи
alkali – щелочь
acid – кислота
to apply – применять
to solder – паять, спаивать
alloy – сплав
joint – тех. соединение
to constitute – составлять, основывать
installation – установка
beam – луч
laser – лазер

Exercises

43.1 Read the following words:

generation, available, thermal, chemical, alkali, acid, voltaic, cell, thermocouple, physicist, machinery, efficiently, laser, armature, source.

43.2 Answer the following questions:

1. What are the principal methods of current generation?
2. What does a group of two or more batteries form?
3. What did Volta invent?

4. What apparatus is used for producing current by thermal action?
5. What metals are joined to form a thermocouple?
6. What does the term "thermocouple" mean?
7. What is the difference between a chemical reaction and a thermal action?
8. How is a current generated by magnetic action?

43.3 Translate the following sentences and define the non-finite forms of the verb:

1. Faraday is known to have measured the electric current for the first time in the world.
2. The magnet being moved into the coil, the wire of the coil cuts the lines of magnetic force and an e. m. f. is produced by induction.
3. To convert heat directly into electrical energy, we must take two wires of dissimilar metals, solder the ends to make a closed circuit and then heat the point of the joint.
4. To convert heat directly into electrical energy is not difficult at all.
5. Charging the electroscope positively, we find that the light does not influence the discharge rate of the electroscope.
6. Charging the electroscope positively does not affect the electroscope discharge rate.
7. The instrument to be described here was developed several years ago.
8. The temperature rising, the bodies expand, their volume increasing.
9. On connecting the upper ends of the metals with a metal wire, we made the current flow through that wire.
10. Electricians consider silver and copper to be the best conductors of electricity.
11. There are many good conductors of electricity, silver and copper being the best of all.

43.4 Translate the following words and define their part of speech:

1. consider, consideration, considerable, considerably, reconsider;
2. generate, generation, generator, degenerate;
3. efficient, efficiency, efficiently;
4. construction, construct, constructor, reconstruct, reconstruction, constructive;

5. convert, conversion, convertible, converter, reconvert.

44 Sources of electrical energy

It was discovered that electric currents might be provided by chemical action in cells or batteries. Thus, in the case of the battery, chemical energy is converted into electricity. However, a battery is by no means the only source of electric energy. It is well known that electricity may also be obtained by other means. For instance, it may be got at the expense of mechanical power.

There are numerous ways and various installations by means of which one can obtain mechanical energy, i. e., work. Among these we find the electric motor as well as the steam and water turbines.

According to the Law of the Conservation and Transformation of Energy, it is impossible to create or destroy energy but it can be converted from one form to another.

In rotating the armature of a generator, mechanical energy (work) is converted into electrical energy. Quite the opposite, in operating a motor, electrical energy is reconverted into mechanical energy (fig. 44-1). One cannot but add in this connection that it is sufficient to connect a generator and a motor together by means of an insulated wire in order to transmit power to any distance desired.

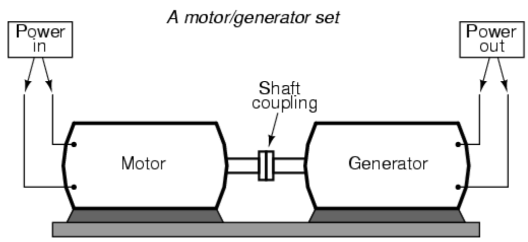


Fig. 44-1. A motor generator set

It is obvious, however, that a country's power engineering resources depend not only on its hydro-resources alone. Power may be obtained as well from any kind of generating station.

Vocabulary:

source – источник
to convert – превращать, переделывать
to obtain – получать
expense – трата, расход
numerous – многочисленный
installation – установка
to create – создавать, творить
to destroy – разрушать
to rotate – вращаться
armature – арматура; эл. якорь
sufficient – достаточный
obvious – очевидно

Exercises:

44.1 Read the following words:

source, chemical, mechanical, numerous, law, armature, require, desire, hydroelectric, giant, thermal, nuclear, commercial.

44.2 Answer the following questions:

1. What are the means of obtaining electrical energy?
2. Can an electrical current be provided only by chemical action?
3. Is a battery the only source of electrical energy?
4. What are the sources of electrical energy?
5. What are the ways of obtaining mechanical energy?
6. Is it possible to destroy energy?
7. Does a generator convert electrical energy into mechanical energy?

44.3 Complete the following sentences:

1. It is interesting to ...
2. It is obvious that ...
3. It is known that ...
4. It is necessary to ...

5. It is said that ...
6. One must know that ...
7. She was asked to…
8. One can say that...
10. One should remember that...

44.4 Translate the following sentences:

1. It is known that energy cannot be created.
2. You are asked to give some examples of energy transformation.
3. It is impossible to create energy.
4. The construction of large thermal power plants is paid great attention to.
5. One must be very careful when operating a nuclear reactor.
6. They employ new devices to obtain better results.
7. This mechanism is believed to be the best for converting heat into work.
8. One could not obtain results without repeating the test.
9. This old type generator is said to have many disadvantages.

44.5 Find in the article attributes for the following nouns:

work, energy, plant, pressure, way, installation, turbine, motor, power, action, temperature, resources.

45 Electric motors

We know that a motor is an electric rotating machine converting electrical energy into mechanical energy.

Mechanical energy furnished by a water wheel or an engine is converted by a generator into electrical energy. To utilize that generated energy, we need another machine that will reverse the process, that is, will reconvert electrical energy back into mechanical energy. Such a machine is the electric motor. Here, it is electricity that is furnished to the machine; it is mechanical energy (work) that results.

Electric motors are used in industry, transport, mines, business, farms and even houses. They are the moving elements in various household appliances, such as vacuum cleaner, washing machine, refrigerator, and the like.

Trams, local trains and trolley buses are powered by electric motors, thus, providing cities with clean, fast, comfortable transportation.

And in each of the places, where they work, the electric motors produce just the desirable kind of motion, speed, and power. As is well known, for uniformity and interchangeability motors are standardized in sizes, types, and speeds. They are available in various sizes from but a small fraction of a horse-power (h. p.) to many thousands of horse-power. Motors are also available in a wide range of speeds. Their speed may be fixed (or synchronous), constant for given load conditions, adjustable, or variable. Many are self-starting and reversible. They can meet a wide range of service requirements, namely: starting, accelerating, running, braking, and stopping the load.

Because of the widespread availability of alternating-current power, a. c. motors are in common use. There are many types of such motors, each of them having special characteristics or properties. They are generally classified by principle of operation, by the type of construction, and the like. Induction motors are the most common a. c. motors. The current in their rotor is induced as the motor conductors cut the lines of the magnetic flux created by the stator. Three-phase induction motors are self-starting, simple, reliable motors with a constant speed characteristic over the rated load limits. We know of their being successfully used in industry. As for single-phase induction motors, they require special means of starting, nevertheless, they are widely used in fractional horse-power sizes.

Electric motor

Vocabulary:

to furnish – снабжать, предоставлять
wheel – колесо
engine – двигатель
household – домашний
desirable – желательный, подходящий
uniformity – единообразие
fraction – частица, доля; дробь
adjustable – регулируемый
load – нагрузка
reliable – надежный, прочный
single-phase – однофазный
range – ряд, линия; область
variable – переменный
interchangeable – взаимозаменяемый
similar – похожий
flux – поток

Exercises

45.1 Read the following words:

person, machine, mechanical, wheel, utilize, reverse, nevertheless, interchangeable, numerous, advantage, irreplaceable, atmosphere, synchronous, stator, torque.

45.2 Answer the following questions:

1. What is a motor?
2. What machine reconverts electrical energy into mechanical energy?
3. Can we do without motors?
4. Where are motors used?
5. In what household appliances are the motors used?

6. How are the motors classified?
7. What are the most common motors?

45.3 Form nouns from the following verbs, using various suffixes and translate them:

to generate, to utilize, to consider, to produce, to require, to accelerate, to classify, to construct, to induce, to create, to transport, to apply.

45.4 Explain the construction of the following words:

flashlight, bookbinder, fatherland, loudspeaker, widespread, waterfall, nevertheless, microampere, radioset, airplane, newspaper, shortcircuit, thermocouple.

45.5 From the words given below form new words using negative prefixes: "in-", "ir-", "dis-", "un-", "im-":

similar, expensive, reversible, reliable, replaceable, convenient, economical, to like, possible, successful, desirable, measurable, available.

46 Transformers

A transformer cannot be called a machine for it has no moving parts. We know the transformer to be an apparatus designed for changing the alternating voltages and currents by means of magnetic induction, the frequency remaining unchanged (fig. 46-1).

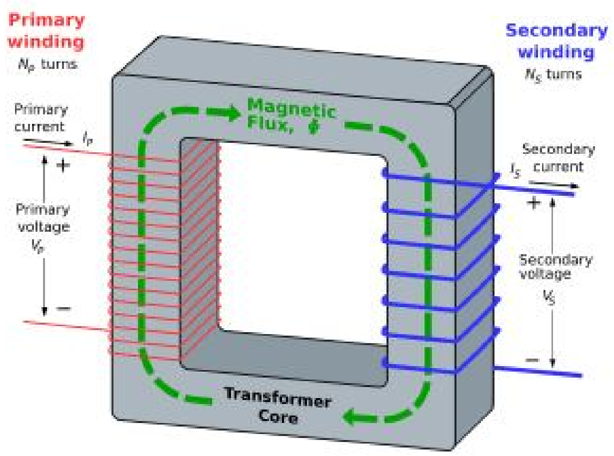


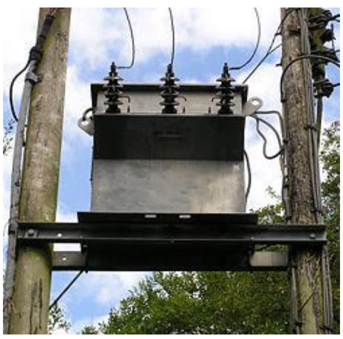
Fig.46-1. An ideal step-down transformer showing magnetic flux in the core

A two-winding transformer consists of two coils, that is windings, so arranged that the magnetic lines of force of one coil pass through the other. Transformers being generally used only with alternating current, there is no need to make and break the circuit. The alternating current in one coil induces an e. m. f. in the other one because of the alternations in the value of the current in the first coil.

In order to strengthen the magnetic field passing through the windings of a transformer, a closed iron core is generally used. The iron core provides a good passage for the magnetic lines of force and nearly all the lines of force from one coil do pass through the other, except the dissipation flux. An ideal transformer has no no-load losses. It means that all the lines of force of one coil pass through the other, and vice versa. However, an ordinary transformer is supposed to have no-load losses.

The winding to receive the electrical energy is called the primary winding, or primary, for short. The other winding which receives energy inductively from the primary and delivers it to the load is the secondary winding, or secondary, for short. In case, the secondary has more turns than the primary, the output voltage is larger than the input voltage, and the transformer is called then a step-up transformer. The secondary having fewer turns than the primary, the transformer is called a step-down transformer. In a well built transformer the product of the secondary voltage multiplied by the secondary current is almost equal to the product of the primary voltage times the primary current.

If the same number of magnetic lines of force pass through two coils, the ratio of the e. m. f.'s to be induced in the two coils is proportional to the ratio of the number of turns in the two coils. In the transformer this means that the e. m. f. in the secondary is to the e. m. f. in the primary as the number of turns in the secondary is to the number of turns in the primary.



Transformer

The transformer has made long-distance power transmission economically possible. Owing to this device the power may be transmitted at a high voltage and reduced at the point where it is to be used.

It is the step-up transformer that should be used to raise the voltage of alternating-current generators, i. e., alternators, so that electrical energy would be transmitted economically at high voltages and low currents. In its turn, the step-down transformer reduces the high voltages to save values suitable for motors and other machines.

Ordinarily transformers are expected to maintain practically constant terminal voltage at all loads but there are transformers of the so-called constant-current type which are designed to maintain a constant current for all loads, the terminal voltage varying according to the change in load.

Vocabulary:

frequency – частота
coil – катушка
core – сердечник
winding – обмотка
alternation – чередование
value – величина
to strengthen – усилить
dissipation – рассеяние
loss – потеря
primary – первичный
secondary – вторичный
to receive – получать
to deliver – доставлять

turn – виток
step-up – повышать
step-down – понижать
to reduce – сокращать

Exercises

46.1 Read the following words:

transformer, machine, design, winding, frequency, arrange, through, break, value, passage, vice versa, primary, ratio.

46.2 Answer the following questions:

1. Is a transformer a machine?
2. What does a two-winding transformer consist of?
3. What is a transformer designed for?
4. Why does the a. c. in one coil induce an e. m. f. in the other?
5. What does the term "primary winding" mean?
6. What is the difference between a step-up transformer and a step-down transformer?
7. Is it possible to transmit power over long distances?

46.3 Translate into English the following sentences:

1. Известно, что трансформатор меняет напряжение и ток.
2. Мы знаем что переменный ток в одной катушке индуцирует э.д.с. в другой.
3. Вторичная обмотка трансформатора подает ток к нагрузке.
4. Трансформатор используется для изменения напряжения в цепи.
5. Благодаря трансформатору стало возможно передавать энергию на большие расстояния.
6. Первичная катушка в понижающем трансформаторе имеет больше витков чем вторичная.
7. Иногда трансформатор применяют для изолирования двух электрических цепей.
8. Переменное напряжение можно повышать и понижать при помощи трансформатора.

46.4 State if the following sentences are true to the fact or false. Correct the false sentences.

1. We can say that a transformer is a machine.
2. Direct current transformers are widely used in industry.
3. A transformer has no moving parts.
4. A transformer can step the voltage up or down.
5. Mechanical energy can be changed into electric energy by means of a transformer.
6. If the secondary has more turns than the primary the output voltage is larger than the input voltage.
7. The lines of force from one coil pass through the dissipation flux.

PART 4. TEXTS FOR ADDITIONAL READING

Mikchail Lomonosov

M. Lomonosov

(1711-1765)

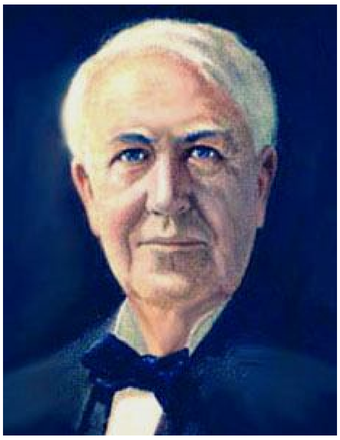
Mikchail Lomonosov, the great Russian scientist and poet, was a son of a fisherman. His first years of study were difficult. He studied at the Slavonic-Greek-Latin Academy in Moscow. Later on he continued his studies in Petersburg and then abroad. Lomonosov founded our first university, the Moscow University, named after him. He founded the first chemical laboratory in Russia, he taught chemistry and other subjects at the Academy of Sciences.

He formulated the main principles of one of the basic laws of physics – the law of conservation of matter and motion. He asserted that all matter was made up of minute particles which he called "elements" and "corpuscles". By "corpuscles" he meant compound particles consisting of simple particles – "elements". Now we say molecules and atoms. It is remarkable that the difference between the molecule and the atom made clear by Lomonosov was precisely formulated for the second time at a special international congress of chemists only a hundred years later. Lomonosov maintained that since "corpuscules" and "elements" represent infinitely small bodies, possessing all the properties of an ordinary body, their motion and interaction follow the general laws of mechanics. As mechanics, Lomonosov set himself a problem, very unusual for his time, — that of creating "mathematical chemistry". Lomonosov was the first who gave the idea about absolute zero. He translated a course in physics from German into Russian and introduced into the Russian scientific language such terms as thermometer, formula, atmosphere and some others.

Lomonosov also found that heat, light and electricity are different forms of motion. He and his friend, academician Rihman, both worked at the problem of atmospheric electricity and stated the electrostatic nature of electricity in atmosphere.

He devoted his whole life to the development of Russian science, and all that he did he did for his people and for his country.

Thomas Alva Edison



Thomas Edison
(1847-1931)

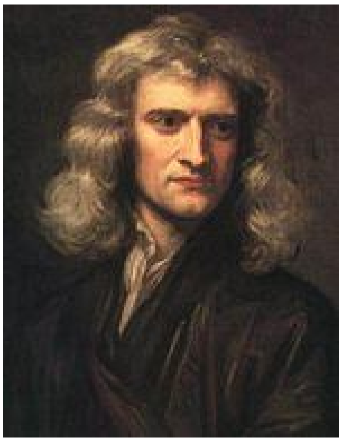
The name of Thomas Alva Edison is widely known throughout the world. The most famous of all his contributions was the improvement of the electric lamp. Thus, highly appreciating Lodygin's invention, Edison went further and worked out a more efficient incandescent filament lamp that was durable, cheap and suitable for the large-scale production. It is also owing to Edison that an efficient system of electric light distribution was carried out, due to which the widespread use of this lamp became possible. Edison was a self-taught man, his schooling being limited to three months in a public school. In spite of this, from early childhood he displayed an intense curiosity as well as a great capacity for work and study. He began to experiment at the age of ten or eleven. Instead of a laboratory he used the cellar of his parents' house.

Later on, Edison had to overcome many difficulties because of the lack of money and assistance. Many years had passed before he could dispose of laboratories and workshops of his own. Thanks to his native genius, his capacity for work (for months he slept no more than one or two hours a day) and the profound study he made of every problem he worked at, he headed technical research in his country and enriched humanity with his numerous inventions.

Isaak Newton

Isaak Newton was born in a farmer's house on December 25, 1642 in a little village not far from the old university town of Cambridge.

His family wanted him to become a farmer, but with no success, as his mind was always busy with observing various phenomena of nature. He studied at Cambridge at mathematical course. Some years later after having taken his degree he was appointed professor to the chair of physics and mathematics at Cambridge. He delivered lectures in optics.



Isaac Newton
(1642-1727)

The study of light was Newton's favorite study. He came to the conclusion that white light consisted of rays of different colours and that each particular kind of coloured ray was differently bent when it fell on a glass surface at the angle. His results formed the bases of modern spectrography. The theory of gravity was developed by him when he was only 24. Having seen the fall of an apple he came to the conclusion that the apple and the earth were pulling each other, and he began to think of the same pull of gravity extending far beyond the earth. The problem of the paths of the planets, one of the greatest problems of those times, was "What laws could account for the ceaseless motion of the planets round the Sun?" Newton deduced and calculated the force of gravity acting between the Sun and the planets, thus establishing the law of gravitation. By discovering this law, he demonstrated the uniformity of things and found a connecting link between the mechanics of the earth and the mechanics of the heavens.

Newton’s mechanics was the first complete theory in the history of physics. (and science in general) which described a large class of phenomena , viz. the motion of bodies. One of Newton’s contemporaries expressed his admiration at this theory in the following verses:

Nature and nature’s Laws
Lay hid in night;
God said, *Let Newton be*
And all was light.

Benjamin Franklin

Benjamin Franklin is acknowledged to be the founder of the theory of atmosheric electricity. He was the first to prove that the lighting was an electrical phenomenon. Franklin developed a new theory of electricity that he called positive and negative. He finally invented a means of protection against the disastrous effects of lighting - the lighting rod.

Benjamin Franklin (1706-1790)

Franklin is known and respected all over the world not only as a scientist but also as a citizen who did as much as he could for the *good* of his country. Coming out in defence of the Afro-Americans, Franklin declared slavery to be not only an evil from the moral point of view, but also an obstacle to the social interests of America. He is thought to be one of the broadest as well as one of the most creative minds of his time.

Michael Faraday

Michael Faraday was born in a small village near London. His father, a poor blacksmith, could feed and clothe his family with difficulty but was entirely unable to afford the luxury of an education for his boy. Michael had to work, and he had to learn a trade. When a boy of 13, he became an errand-boy and later on a bookbinder's apprentice.

Some of the scientific books passing through his hands aroused the boy's interest in science.

Notwithstanding his scant wages, he used to buy inexpensive materials to make an apparatus necessary for performing experiments.

Finding the apprentice studying electricity, a visitor to the bookbinder's shop gave him tickets to attend four lectures by Humphry Davy. While at the lectures, Faraday listened, understood everything and put down every word. Then, at home, in his room, he wrote Davy a letter, telling him of his great interest in science and his desire, to do scientific work.

They say that Davy was a scientist well known for his researches and discoveries but his greatest discovery was Michael Faraday.

Michael Faraday
(1791-1867)

In his lifetime, Faraday performed more than two thousand laborious experiments and made countless valuable discoveries in chemistry and physics. What we are most interested in here is just one discovery of his, namely, the generation of electricity from magnetism.

The fact that electricity could produce magnetic effects turned his thoughts towards the reverse possibility – that of generating electricity owing to magnetic effects.

It is characteristic of him that when he gave up the varied scientific interests that had taken all his time and concentrated on the problem of electromagnetic induction, he solved it within ten working days.

Faraday wound a copper wire into a coil, and to this wire he connected a galvanometer in order to detect any current which might be generated. He observed the galvanometer needle move both while plunging a bar magnet into the hollow coil and while lifting it out. Evidently, electricity had been produced in the coil. But why had his previous experiments failed? It was because his magnets, wires, and coils had been stationary. It was only when the magnet was moving that an electric current was generated.

As known all over the world, on October 17, 1831, Faraday made his historic discovery, namely, induction of a current in a conductor resulted when the conductor was made to cut the lines of magnetic force.

Lodygin

The creation of the first incandescent lamp is closely connected with the name of the well-known Russian scientist and inventor, Alexander Nicolayevitch Lodygin.

Lodygin created the first incandescent lamp and laid the foundation for the production of the present-day incandescent lamps that are much more economical than the lamps with carbon electrodes. Lodygin was the first to turn a laboratory device into a means of electric lighting. He was also the first inventor to discover the advantages of the metal wire filaments in comparison with other filaments.

Alexander Lodygin
(1847-1923)

Lodygin's great achievements paved the way for further of successful work a number of other Russian electrical engineers.

In 1872 Lodygin constructed a number of incandescent lamps, these first lamps consisting of a glass bulb with a carbon rod serving as a filament.

In 1873 he produced an improved lamp having two carbon electrodes instead of one and a longer life (about 2 hours and even 2 hours and a half).

That very year Lodygin demonstrated his invention in several Petersburg streets, lighting them by means of his electric lamps. It was the first practical application of the incandescent lamp for lighting purposes. Lots of people went out into the street to see electric light for the first time in their life and, as a matter of fact, for the first time in the world.

Lodygin was never satisfied with his achievements and continued to perfect his invention. Indeed, a more perfect lamp designed by him appeared in 1875. The interest in Lodygin's lamp greatly increased. However, under very hard economic conditions existing in tsarist Russia he got neither the help nor the necessary support to realize his plans. He himself was practically without money, having spent all he had on his numerous experiments.

Lodygin's study of metal filaments having a high melting point is a work of world importance. It is he who introduced tungsten filaments in a vacuum. He received a patent for his invention in America. Tungsten is still considered to be the very metal that should be used for filament production.

Automation

Automation is performing certain tasks, previously done by people, by machines only. The sequences of operations are controlled automatically. The most familiar example of a highly automated system is an assembly plant for automobiles or other complex products.

Industrial robots engaged in vehicle underbody assembly

The term automation is also used to describe nonmanufacturing systems in which automatic devices can operate independently of human control. Such devices as automatic pilots, automatic telephone equipment and automated control systems are used to perform various operations much faster and better than could be done by people.

Automated manufacturing had several steps in its development. Mechanization was the first step necessary in the development of automation. The simplification of work made it possible to design and build machines that resembled the motions of the worker. These specialized machines were motorized and they had better production efficiency.

Industrial robots, originally designed only to perform simple tasks in environments dangerous to human workers, are now widely used to transfer, manipulate, and position both light and heavy workpieces performing all the functions of a transfer machine.

In the 1920s the automobile industry for the first time used an integrated system of production. This method of production was adopted by most car manufacturers and became known as Detroit automation.

The feedback principle is used in all automatic-control mechanisms when machines have ability to correct themselves. The feedback principle has been used for centuries. An outstanding early example is the flyball governor, invented in1788 by James Watt to control the speed of the steam engine. The common household thermostat is another example of a feedback device.

Using feedback devices, machines can start, stop, speed up, slow down, count, inspect, test, compare, and measure. These operations are commonly applied to a wide variety of production operations.

Computers have greatly facilitated the use of feedback in manufacturing processes. Computers gave rise to the development of numerically controlled machines. The motions of these machines are controlled machines. The motions of these machines are controlled by punched paper or magnetic tapes. In numerically controlled machining centres machine tools can perform several different machining operations.

More recently, the introduction of microprocessors and computers has made possible the development of computer-aided design and computer-aided manufacture (CAD and CAM) technologies. When using these systems a designer draws a part and indicates its dimensions with the help of a mouse, light pen, or other input device. After the drawing has been completed the computer automatically gives the instructions that direct a machining centre to machine the part.

Another development using automation is the flexible manufacturing systems (FMS). A computer in FMS can be used to monitor and control the operation of the whole factory.

Automation has also had an influence on the areas of the economy other than manufacturing.

Many industries are highly automated or use automation technology in some part of the operation. In communications and especially in the telephone industry dialing and transmission are all done automatically. Railways are also controlled by automatic signaling devices, which have sensors that detect carriages passing a particular point. In this way the movement and location of trains can be monitored.

Types of automation

Manufacturing is one of the important application fields for automation technology. There are several types of automation in manufacturing. The examples of automated systems used in manufacturing are described below.

1. Fixed automation, sometimes called "hard automation" refers to automated machines in which the equipment configuration allows fixed sequence of processing operations. These machines are programmed by their design to make only certain processing operations. They are not easily changed over from one product to another. This form of automation needs high initial investments and high production rates. That is why it is suitable for products that are made in large volumes. Examples of fixed automation are machining transfer lines found in the automobile industry, automatic assembly machines and certain chemical processes.

2. Programmable automation is a form of automation for producing products in large quantities, ranging from several dozen to several thousand units a time. For each new product the production equipment must be reprogrammed and changed over. This reprogramming and changeover take a period of non-productive time. Production rates in programmable automation are generally lower than in fixed automation, because the equipment is designed to facilitate product changeover rather than for product specialization. A numerical-control machine-tool is a

good example of programmable automation. The programme is coded in computer memory for each different product style and the machine-tool is controlled by the computer programme.

3. Flexible automation is a kind of programmable automation. Programmable automation requires time to reprogram and change over the production equipment for each series of new product. This is lost production time, which is expensive. In flexible automation the number of products is limited so that the changeover of the equipment can be done very quickly and automatically. The reprogramming of the equipment in flexible automation is done at a computer terminal without using the production equipment itself. Flexible automation allows a mixture of different products to be produced one right after another.

Robots in industry

Today most robots are used in manufacturing operations. The applications of robots can be divided into three categories:

1. material handling
2. processing operations
3. assembly and inspection.

Material-handling is the transfer of material and loading and unloading of machines. Material-transfer applications require the robot to move materials or work parts from one to another. Many of these tasks are relatively simple: robots pick up parts from one conveyor and place them on another. Other transfer operations are more complex, such as placing parts in an arrangement that can be calculated by the robot. Machine loading and unloading operations utilize a robot to load and unload parts. This requires the robot to be equipped with a gripper that can grasp parts. Usually the gripper must be designed specifically for the particular part geometry.

Robots in industry

In processing operations robot manipulates a tool to perform a process on the work part. Examples of such applications include spot welding, continuous arc welding and spray painting. Spot welding of automobile bodies is one of the most common applications of industrial robots. The robot positions a spot welder against the automobile panels and frames to join them. Arc welding is a continuous process in which robot moves the welding rod along the welding seam. Spray painting is the manipulation of a spray-painting gun over the surface of the object to be coated. Other operations in this category include grinding and polishing in which a rotating spindle serves as the robot's tool.

The third application area of industrial robots is assembly and inspection. The use of robots in assembly is expected to increase because of the high cost of manual labour. But the design of the product is an important aspect of robotic assembly. Assembly methods that are satisfactory for humans are not always suitable for robots. Screws and nuts are widely used for fastening in manual assembly, but the same operations are extremely difficult for a one-armed robot.

Inspection is another area of factory operations in which the utilization of robots is growing. In a typical inspection job, the robot positions a sensor with respect to the work part and determines whether the part answers the quality specifications. In nearly all industrial robotic applications, the robot provides a substitute for human labour. There are certain characteristics of industrial jobs performed by humans that can be done by robots:

1. the operation is repetitive, involving the same basic work motions every cycle,

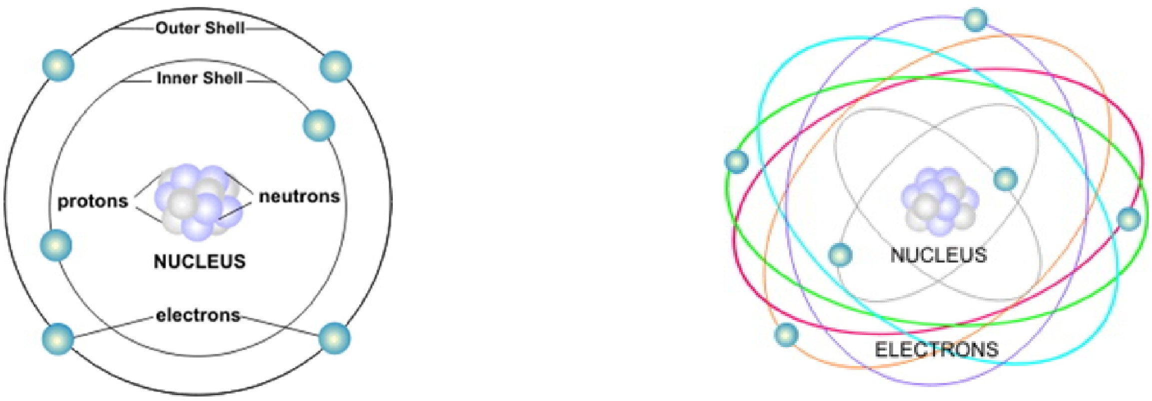
2.the operation is hazardous or uncomfortable for the human worker (for example: spray painting, spot welding, arc welding, and certain machine loading and unloading tasks),

3.the workpiece or tool are too heavy and difficult to handle,

4.the operation allows the robot to be used on two or three shifts.

The science of electricity

In order to understand how electric charge moves from one atom to another, we need to know something about atoms. Everything in the universe is made of atoms — every star, every tree, every animal. The human body is made of atoms. Air and water are, too. Atoms are the building blocks of the universe. Atoms are so small that millions of them would fit on the head of a pin.



An atom

Atoms are made of even smaller particles. The center of an atom is called the **nucleus**. It is made of particles called **protons** and **neutrons**. The protons and neutrons are very small, but electrons are much, much smaller. **Electrons** spin around the nucleus in shells a great distance from the nucleus. If the nucleus were the size of a tennis ball, the atom would be the size of the Empire State Building. Atoms are mostly empty space.

If you could see an atom, it would look a little like a tiny center of balls surrounded by giant invisible bubbles (or shells). The electrons would be on the surface of the bubbles, constantly spinning and moving to stay as far away from each other as possible. Electrons are held in their shells by an electrical force.

The protons and electrons of an atom are attracted to each other. They both carry an electrical charge. An electrical charge is a force within the particle. Protons have a positive charge (+) and electrons have a negative charge (-). The positive charge of the protons is equal to the negative charge of the electrons. Opposite charges attract each other. When an atom is in balance, it has an equal number of protons and electrons. The neutrons carry no charge and their number can vary.

The number of protons in an atom determines the kind of atom, or **element**, it is. An element is a substance in which all of the atoms are identical (the Periodic Table shows all the known elements). Every atom of hydrogen, for example, has one proton and one electron, with no neutrons. Every atom of carbon has six protons, six electrons, and six neutrons. The number of protons determines which element it is.

Electrons usually remain a constant distance from the nucleus in precise **shells**. The shell closest to the nucleus can hold two electrons. The next shell can hold up to eight. The outer shells cans hold even more. Some atoms with many protons can have as many as seven shells with electrons in them.

The electrons in the shells closest to the nucleus have a strong force of attraction to the protons. Sometimes, the electrons in the outermost shells do not. These electrons can be pushed out of their orbits. Applying a force can make them move from one atom to another. These moving electrons are electricity.

Sources of energy

We use many different energy sources to do work for us. Energy sources are classified into two groups — renewable and nonrenewable. Renewable and nonrenewable energy can be converted into secondary energy sources like electricity and hydrogen.

In some countries most of our energy comes from nonrenewable energy sources. Coal, petroleum, natural gas, propane, and uranium are nonrenewable energy sources. They are used to make electricity, to heat our homes, to move our cars, and to manufacture all kinds of products.

These energy sources are called nonrenewable because their supplies are limited. Petroleum, for example, was formed millions of years ago from the remains of ancient sea plants and animals. We can't make more petroleum in a short time.

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable energy sources because they are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Electricity and hydrogen are different from the other energy sources because they are secondary sources of energy. Secondary sources of energy — energy carriers — are used to store, move, and deliver energy in easily usable form. We have to use another energy source to make electricity or hydrogen. In the United States, coal is the number one energy source for generating electricity. Today the cheapest way to get hydrogen is by separating it from natural gas, a nonrenewable energy source. Hydrogen can also be separated from water and from renewables but hydrogen made from these sources is currently too expensive to compete with other fuels. Scientists are working on ways to make hydrogen from water and renewables more affordable.

Wind power is of increasing importance in many countries

A secondary source

Electricity is the flow of electrical power or charge. It is a secondary energy source which means that we get it from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources, which are called primary sources. The energy sources we use to make electricity can be renewable or non-renewable, but electricity itself is neither renewable or non-renewable.

Electricity is a basic part of nature and it is one of our most widely used forms of energy. Many cities and towns were built alongside waterfalls (a primary source of mechanical energy) that turned water wheels to perform work. Before electricity generation began slightly over 100 years ago, houses were lit with kerosene lamps, food was cooled in iceboxes, and rooms were warmed by wood-burning or coal-burning stoves. Beginning with Benjamin Franklin’s experiment with a kite one stormy night in Philadelphia, the principles of electricity gradually became understood. Thomas Edison helped change everyone's life - he perfected his invention - the electric light bulb. Prior to 1879, direct current (DC) electricity had been used in arc lights for outdoor lighting. In the late-1800s, Nicola Tesla pioneered the generation, transmission, and use of alternating current (AC) electricity, which can be transmitted over much greater distances than direct current. Tesla's inventions used electricity to bring indoor lighting to our homes and to power industrial machines.

Despite its great importance in our daily lives, most of us rarely stop to think what life would be like without electricity. Yet like air and water, we tend to take electricity for granted. Everyday, we use electricity to do many jobs for us - from lighting and heating/cooling our homes, to powering our televisions and computers. Electricity is a controllable and convenient form of energy used in the applications of heat, light and power.

The nature of electricity

Most homes have two incoming voltages: 120 volts for lighting and appliance circuits and 240 volts for larger air conditioning and electric dryer circuits.

When an appliance switch is turned on, electrical current flows through the wire, completing the electrical "circuit" and causing the appliance to operate. The amount of flowing current is called "amperage." Most lighting circuits in the home are 15 amp circuits. Most electric dryers and air conditioners require larger 30 amp circuits.

The amount of electrical power needed to make an appliance operate is called "wattage" and is a function of the amount of current flowing through the wire (amperage), and the pressure in the system (voltage).
Mathematically speaking, volts x amps = watts. So, if we have a 120 volt system and a 15 amp current, we can flow a maximum of 120 x 15 or 1,800 watts on a typical lighting or appliance circuit. When too many lights or appliances are attached to the electrical system, it will overload and overheat. This can cause the wire insulation to melt and ignite, resulting in an electrical fire. The amount of electrical current flowing through wire is affected by resistance. This is known as "ohms." Resistance causes increased heat in the wire. Heat is the byproduct that makes some appliances work, such as an iron, toaster, stove or furnace. Large current faces high resistance when moving through a small wire. This generates lots of heat. That's how an incandescent light bulb works. Resistance through the light filament causes it to heat up which gives off a bright light. Electrical resistance also is affected by the length of a wire. Operating an electrical hedge clipper with a long extension cord increases resistance and might cause the cord to overheat, melt or ignite. The same occurs if too many strands of Christmas lights are connected together.

General electrical safety

When a house is under construction, city inspectors visit to make sure the electrical system is in compliance with the City Building Code and the National Electrical Code. Only licensed electricians are permitted to install electrical systems. During home remodeling, when electrical circuits are added or changed, make sure to use a licensed electrician whose work complies with the electrical code. Add enough outlets in every room to avoid using multiple plugs or extension cords. Use a ground fault interrupter (G.F.I.) on circuits in the bathroom, or outdoors where water or moisture is present. G.F.I. is a type of very sensitive circuit breaker.

When choosing an electrical appliance, be sure it is approved by a safety-testing laboratory. This insures that it has been constructed in accordance with nationally-accepted electrical standards and has been evaluated for safety. Use the appliance only according to manufacturer's specific instructions.

If you touch an electrical appliance, wall switch or electrical cord while you are wet or standing in water, it will increase the chance of electrical shock.

When using an extension cord, be sure it is designed to carry the intended load. Most cannot carry as much current as permanent wiring and tend to overheat. Do not use an extension cord in place of permanent wiring, especially if a tripping hazard exists or where there is high physical abuse, such as under a carpet. Keep electrical cords away from infants and toddlers and use tamperproof inserts on wall outlets to prevent them from sticking objects into the outlets. The cord must be protected from damage. Do not run it around objects or hang on a nail. Inspect it periodically for worn insulation and overall condition.

Safety with electrical appliances

The potential for electrical shock or fire from an electrical appliance is very real, especially when safety recommendations are not followed.

Before buying an appliance, look for the label of a recognized testing laboratory.

Keep space heaters, stoves, irons and other heat-producing appliances away from furniture, curtains, bedding or towels. Also, give televisions, stereos and computers plenty of air-space so they won't overheat.

Never use an appliance with a damaged cord, and be sure to use three- pronged electrical devices in three-pronged outlets.

These outlets may not be available in older homes, so use a three-pronged adapter, and screw the tab onto the grounded outlet box cover. Never cut off or bend the grounding pin of the plug. If you have a polarized plug (with one side wider than the other), never file it down or try to make it reversible.

Keep electrical cords out of the path of traffic. If you put cords under carpets or rugs, wires can be damaged and might result in fire.

An electrical cord should never be wrapped around an appliance until the appliance has cooled. Because hair care equipment is often used in bathrooms near sinks and bathtubs, it is extremely important to be especially careful that the appliances do not come in contact with water. If one drops into water, do not touch it until you have pulled the wall plug.

Never put a kitchen knife or other metal object in a toaster to remove stuck bread or bagels unless it is unplugged and cooled. Install television and radio antennas where they cannot fall across power lines. Use caution when operating a tree-pruning device or using a metal ladder around power lines.

Inspect appliances regularly to make sure they operate properly. If an appliance smells funny when in use, makes unusual sounds or the cord feels warm to touch, repair or replace the unit. Don't repair it yourself unless you are qualified. Keep appliances in a cool, dry place to prevent rusting.

Electricity overload leads to bad energy saving decision.

Save electricity, save the environment

By using electricity wisely you can reduce energy wastage. This will reduce the quantity of energy needed to produce electricity. It will also reduce the amount of fossil fuel used at power stations and lead to a reduction in the production of carbon dioxide, steam, sulfur dioxide and the volume of heated water being returned to river systems or lakes (thermal pollution).

Save electricity on heating

Heating your home uses the most electricity. But there are a number of ways you can avoid wasting heat:

- always close doors opening to the outside
- insulate walls and ceilings
- close off areas being heated
- block off chimneys when not in use
- use time switches to provide heating only when it is needed
- install pelmets, and lined curtains which reach the floor
- instead of heating the entire bedroom, use an electric blanket just to warm the bed.

Save electricity on cooling

Well-insulated houses keep warmer in winter and cooler in summer. To cut back on the electricity used for cooling:

- close off rooms and sections not being cooled
- regularly service your air conditioner to make sure it is in good condition
- if using air conditioners set fans to high speed for greater efficiency
- do not set thermostats on air conditioners too low
- if possible leave fresh air and exhaust controls on your air conditioner in the closed position
- shade windows with awnings or curtains.

Save electricity on hot water

About 20 per cent of the electricity used in a household is used to heat water. You can reduce the amount of hot water you use and save energy by:

- installing a water restrictor or low-flow shower

- installing an off-peak electric hot water service
- turning hot water taps off fully and making sure they do not leak
- insulating hot water pipes for at least one metre from the storage tank
- having a short shower instead of a bath
- turning off the hot water system before going away for more than two weeks
- filling the kettle or jug with water from the cold tap instead of the hot tap.

Save electricity in the kitchen

Electricity can be saved with the refrigerator by:

- making sure the seals on the door fit properly
- only opening the door when necessary
- defrosting the freezer before ice builds up
- keeping the condenser coils and seals dust-free

Energy can be saved when using the dishwasher by:

- waiting until the dishwasher has a full load
- rinsing dirty plates in a sink of cold water
- using a good quality detergent
- using energy saving cycles.

Save electricity with lighting

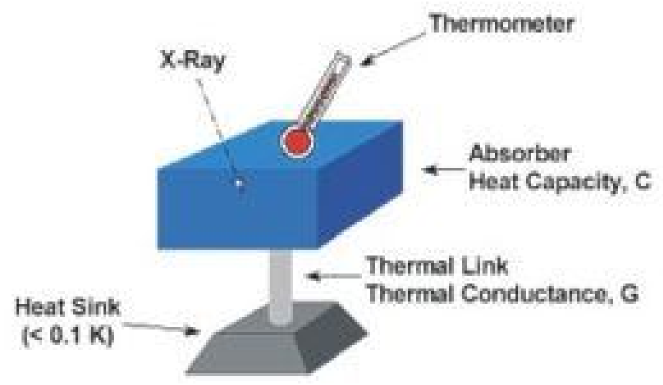
Lighting accounts for 4 per cent of household energy use.
Try these ways to save electricity:

- turn lights off when leaving the room
- use fluorescent tubes and lights - they use a quarter of the electricity of ordinary globes and last up to four times longer
- choose lamps which do not filter the light and position them in a corner to reflect their light off the walls
- light the whole room only when necessary
- use light globes with lower wattage and put them in places where they will give the best light

Measurement

There is no absolute measure of energy, because energy is defined as the work that one system does (or can do) on another. Thus, only of the transition of a system from one state into another can be defined and thus measured.

The methods for the measurement of energy often deploy methods for the measurement of still more fundamental concepts of science, namely mass, distance, radiation, temperature, time, electric charge and electric current.



A calorimeter - an instrument used by physicists to measure energy

Conventionally the technique most often employed is calorimetry, a thermodynamic technique that relies on the measurement of temperature using a thermometer or of intensity of radiation using a bolometer.

Throughout the history of science, energy has been expressed in several different units such as ergs and calories. At present, the accepted unit of measurement for energy is the SI unit of energy, the joule.

The Sun

The Sun is the most important of all heavenly bodies of our solar system. Without the Sun there would be no light, no heat, no energy of any kind.

The Sun is a mass of flaming matter. The surface temperature of the Sun is about 10,000°F , in the interior of the Sun the temperatures are much higher, rising to 30,000,000°F. Much of the radiation from the Sun is absorbed by the atmosphere before it reaches the

Earth's surface.

The Sun's diameter is more than one million kilometres. Its bulk is a million and a quarter times the bulk of our Earth. These figures are hard to imagine. If a bullet from a gun towards the sun kept its velocity constant, it would take seven years to reach the Sun. Still, we say the Sun is close, measured by the scale of the stars.

The Sun

If the Earth were a small ball, 3 cm. in diameter, the Sun would be a globe 274 cm. in diameter. The Sun turns on its axis in about 25 days. Scientists consider that life has existed on the Earth for more than 500 million years. During all this time the solar constant couldn't have changed greatly. Both the solar distance and the Sun's rate of generation of radiation must have varied little over this period of time.

Electric power plants

Electric power is generated at electric power plants. The main unit of an electric power plant comprises a prime mover and the generator which it rotates.

In order to actuate the prime mover energy is required. Many different sources of energy are in use nowadays. To these sources belong heat obtained by burning fuels, pressure due to the flow of air (wind), solar heat, etc.

According to the kind of energy used by the prime mover, power plants are divided into groups. Thermal, hydraulic (water-power) and wind plants form these groups. According to the kind of prime mover, electric power plants are classed as:

a) Steam turbine plants, where steam turbines serve as prime movers. The main generating units at steam turbine plants belong to the modern, high-capacity class of power plants.
b) Steam engine plants, in which the prime mover is a piston-type steam engine.

Nowadays no large generating plants of industrial importance are constructed with such prime movers. They are used only for local power supply.

c) Diesel-engine plants; in them diesel internal combustion engines are installed. These plants are also of small capacity, they are employed for local power supply.
d) Hydroelectric power plants employ water turbines as prime movers. Therefore they are called hydroturbine plants. Their main generating unit is the hydrogenerator.

Modern wind-electric power plants utilize various turbines; these plants as well as the small capacity hydroelectric power plants are widely used in agriculture.

Electrical phenomena in nature

Electricity is by no means a purely human invention, and may be observed in several forms in nature, a prominent manifestation of which is lighting. 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 cane sugar, generate a potential difference across their faces when subjected to external pressure. This phenomenon is known as piezoelectricity, from the Greek *piezein*, 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 electrocytes. 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. They are also responsible for coordinating activities in certain plants.

The electric eel, *Electrophorus electricus*

Electric power

Electric power is the rate at which electrical energy is produced or consumed, and is measured in watts (symbol: W).

A nuclear power station.

A fossil-fuel or nuclear power station converts heat to electrical energy, and the faster the station burns fuel, assuming constant efficiency of conversion, the higher its power output. The output of a power station is usually specified in megawatts (millions of watts). The electrical energy is then sent over transmission lines to reach the consumers.

Each consumer uses appliances that convert the electrical energy to other forms of energy, such as heat (in electric arc furnaces and electric heaters), light (in light bulbs and fluorescent lamps), or motion, i.e. kinetic energy (in electric motors). Like the power station, each appliance is also rated in watts, depending on the rate at which it converts electrical energy into another form. The power station must produce electrical energy at the same rate as all the connected appliances consume it.

In electrical engineering, the concepts of apparent power and reactive power are also used. Apparent power is the product of RMS voltage and RMS current, and is measured in volt-amperes (VA). Reactive power is measured in volt-amperes-reactive (VAR).

Non-nuclear electric power is categorized as either green or brown electricity.

Green power is a cleaner alternative energy source in comparison to traditional sources, and is derived from renewable energy resources that do not produce any nuclear waste; examples include energy produced from wind, water, solar, thermal, hydro, combustible renewables and waste.

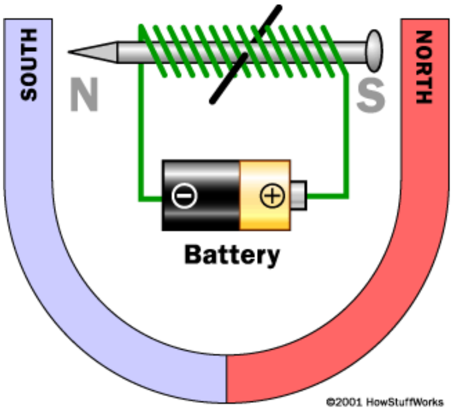
Electricity from coal, oil and natural gas is known as traditional power or “brown” electricity.

Electromagnets and Motors

To understand how an electric motor works, the key is to understand how the electromagnet works.

An electromagnet is the basis of an electric motor. You can understand how things work in the motor by imagining the following scenario. Say that you created a simple electromagnet by wrapping 100 loops of wire around a nail and connecting it to a battery. The nail would become a magnet and have a north and south pole while the battery is connected.

Now say that you take your nail electromagnet, run an axle through the middle of it and suspend it in the middle of a horseshoe magnet as shown in the figure below. If you were to attach a battery to the electromagnet so that the north end of the nail appeared as shown, the basic law of magnetism tells you what would happen: The north end of the electromagnet would be repelled from the north end of the horseshoe magnet and attracted to the south end of the horseshoe magnet. The south end of the electromagnet would be repelled in a similar way. The nail would move about half a turn and then stop in the position shown.



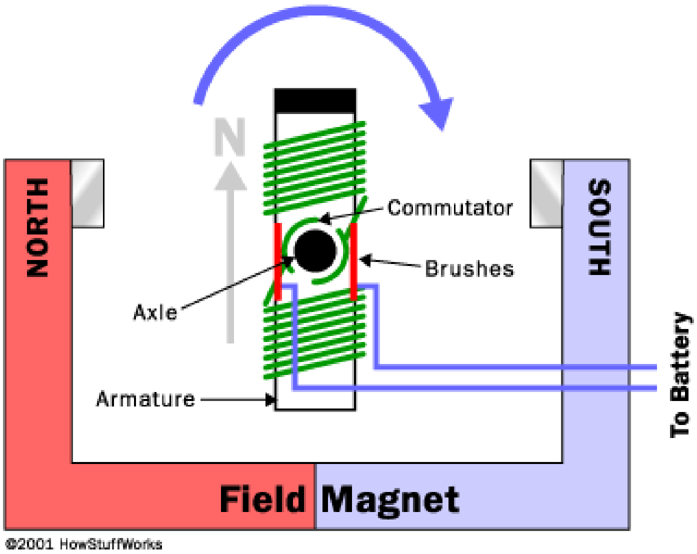
Electromagnet in a horseshoe magnet

You can see that this half-turn of motion is simply due to the way magnets naturally attract and repel one another. The key to an electric motor is to then go one step further so that, at the moment that this half-turn of motion completes, the field of the electromagnet flips**.** The flip causes the electromagnet to complete another half-turn of motion. You flip the magnetic field just by changing the direction of the electrons flowing in the wire (you do that by flipping the battery over). If the field of the electromagnet were flipped at precisely the right moment at the end of each half-turn of motion, the electric motor would spin freely.

Inside an Electric Motor

Let's start by looking at the overall plan of a simple two-pole DC electric motor**.** A simple motor has six parts, as shown in the diagram below:

- Armature or rotor
- Commutator
- Brushes
- Axle
- Field magnet
- DC power supply of some sort



Parts of an electric motor

An electric motor is all about magnets and magnetism: A motor uses magnets to create motion. If you have ever played with magnets you know about the fundamental law of all magnets: Opposites attract and likes repel. So if you have two bar magnets with their ends marked "north" and "south," then the north end of one magnet will attract the south end of the other.

On the other hand, the north end of one magnet will repel the north end of the other (and similarly, south will repel south). Inside an electric motor, these attracting and repelling forces create rotational motion**.**

In the above diagram, you can see two magnets in the motor: The armature (or rotor) is an electromagnet, while the field magnet is a permanent magnet (the field magnet could be an electromagnet as well, but in most small motors it isn't in order to save power).

Motors Everywhere!

Look around your house and you will find that it is filled with electric motors. Here's an interesting experiment for you to try: Walk through your house and count all the motors you find. Starting in the kitchen, there are motors in:

The fan over the stove and in the microwave oven
The dispose-all under the sink
The blender
The can opener
The refrigerator - Two or three in fact: one for the compressor, one for the fan inside the refrigerator, as well as one in the icemaker
The mixer
The tape player in the answering machine
Probably even the clock on the oven

In the utility room, there is an electric motor in:

The washer
The dryer
The electric screwdriver
The vacuum cleaner
The electric saw
The electric drill
The furnace blower

Even in the bathroom, there's a motor in:

The fan
The electric toothbrush
The hair dryer
The electric razor

Your car is loaded with electric motors:

Power windows (a motor in each window)
Power seats (up to seven motors per seat)
Fans for the heater and the radiator
Windshield wipers
The starter motor
Electric radio antennas

Plus, there are motors in all sorts of other places:

Several in the VCR
Several in a CD player or tape deck
Many in a computer (each disk drive has two or three, plus there's a fan or two)
Most toys that move have at least one motor (including Tickle-me-Elmo for its vibrations)
Electric clocks
The garage door opener
Aquarium pumps

APPENDIX

Glossary

A-frame a structural frame in the shape of the letter A

ac alternating current

alloy a metal formed by mixing together other metals and elements

armature the moving part of an electric motor which comprises a piece of iron with loops of wire running round it; the current through the wire is reversed to provide the changes in magnetic fields required to make the motor run

bearing a device to reduce friction and wear between a rotating shaft and a stationary part; may contain balls or rollers

biomass (bio=life) fuel produced from living organisms, e.g. plant matter or methane

block diagram schematic drawing showing different functions in a system or stages in a process

brushes spring-loaded carbon blocks which carry the electric current to the commutator of an electric motor

CAD Computer-Aided Design

CAM Computer-Aided Manufacture

CAPP Computer-Aided Process Planning

charger a device which contains a unit for converting mains power to direct current at a suitable voltage for charging batteries

CIM Computer-Integrated Manufacturing: describes a series of processes or activities coordinated by using a computer

circuit breaker an electrical switch fitted with an overload protection cut out

closed loop a system where part of the output of a system is fed back into the input to modify the output

commutator the part of the armature of an electric motor which is in contact with the brushes; it reverses the flow of current through the armature

compressed air air at higher than atmospheric pressure; used to power pneumatic devices such as drills

compression the effect of forces which act to squash a structure

computer model a representation of a design created in 3D on a computer using a CAD programme

computer-based describes a system which relies on the use of a computer

condenser a unit where vapour is converted back into a liquid

conductor a material which will transmit electricity or heat

corrosion-resistant describes a material which can be used in environments where long-term strength or appearance is important, e.g. stainless steel

corrosive describes a substance which corrodes (eats or wears away), usually by chemical action

cylinder head a plate which seals the ends of cylinders on internal combustion engines; it contains the valves

dc direct current

derivation taking from, e.g. the derivation of fuels from landfills

die a specially shaped block of metal used as a mould for other materials

documentation the complete description of a product in words and drawings at every stage in its manufacture

EDM Engineering Data Management

elastic limit the point at which a material will no longer return to its original shape after tensile forces are released

elasticity the property of a material to stretch and then return to its original state

emissions materials or radiation given off, e.g. air pollution emissions

engine a device which coverts fuel into work

equilibrium balance (a structure is in equilibrium when all the forces on it are stable and there is no movement)

escalator moving stairs

evaporator a unit in which a liquid is converted into a vapour

facilities buildings and factories, e.g. electricity generating facilities

feedback a signal responding to the output of a system which is returned to the input to modify the output

field magnet a magnet for producing and maintaining the magnetic field in a generator or electric motor

fluctuations changes or variations, e.g. seasonal fluctuations in heating oil use

fossil fuels fuels created at the same time as the fossils around them, about 230 to 180 million years ago, e.g. coal, oil and natural gas, also known as "non-renewable" fuels

friction the resistance experienced when two bodies rub against each other

fuel cell a cell which converts the chemical energy of a fuel to electrical energy

geothermal (geo=earth, therm=heat) heat from the earth

grinder a machine with a rotating disc of abrasive material used for sharpening tools and removing rough edges a grinding machine operator

guard a device to safeguard the operators of moving machinery

heat exchanger the part of a boiler where the water is heated

heat-resistant describes a material which will withstand exposure to high temperature

hydraulic describes a system using cylinders and pistons and driven by a fluid

hydroelectric (hydro=water) electricity from water

ignition the circuit which allows high-tension current to pass to the sparking plugs in an internal combustion engine

insulator a substance which will not transmit electricity or heat

interface hardware and software to enable a computer to communicate with the device to be controlled

intermittent part-time, on and off, e.g. solar and wind energy

IT Information Technology

JIT Just-In-Time Manufacturing

laser Light Amplification by Stimulated Emission of Radiation

LCD Liquid Crystal Display

load cell a load-measuring element using an electrical strain gauge as the measuring device

manipulator the part of a robot which carries out the work

methods engineer someone concerned with establishing the best production method and equipment for making an article

micrometer a U-shaped gauge used for precise measurement of thicknesses; the gap between the measuring faces is adjusted by rotating a screw thread encased in a graduated sleeve

microprocessor integrated circuit chip at the centre of a computer for controlling the system and processing the data

mill a milling machine; uses multi-toothed cutters to shape metals and plastics

miller a milling machine operator

MRP materials requirement planning

photovoltaic (photo=light, volt=electricity) electricity from sunlight, e.g. photovoltaic (solar) panels

pilot light a small flame used to ignite the main burners in a gas-fired heating boiler

pitting corrosion due to localized chemical reaction

plant the machines in a factory and all the buildings

pressure regulator a device for adjusting or maintaining pressure levels

prototype the first working model

pulley a grooved wheel over which a rope passes

reaction the force which opposes an applied force

recycling extracting from waste all materials that can be reprocessed to be used again

refrigerant a substance which changes easily from a liquid to a gas and which can be used in refrigeration to remove heat energy and transfer it to the surroundings

remote control a device for controlling something from a distance

renewable something we can grow or collect more of, e.g. wood or sunlight

replenish to replace or put back, e.g. replenish the water in geothermal reservoirs

residue that which remains, leftovers, e.g. the residue from logging operations is small bits of wood, branches and twigs, and sawdust

resultant the single outcome of a number of different vectors

revolve turn, rotate

robotics the study or production of machines which perform tasks in a manner similar to humans

rotor rotating part of a generator

sensing device a device which monitors the operating environment and is sensitive to

signal generator electronic device which produces various signals used in tests and measurements

solenoid a coil with an iron core which is pulled into the coil by a current passing through the coil

solenoid valve a valve operated by a solenoid

spanner a tool, or level, for applying force to nuts and bolts

spring balance a measuring device in which the force applied is calculated by the extension of a spring

stator stationary part of a generator

switchgear switches and associated equipment for controlling large electrical currents

systems analyst someone responsible for examining a problem to see whether it is suitable for a computer application

tension the effect of a pulling force which tends to stretch a body

thermoplastic a plastic which softens when heated and hardens when cooled

thermosetting plastic a plastic which retains its shape and rigidity at high temperatures

thermostat a control device which operates at a pre-set temperature

tooling all manufacturing equipment required for the manufacture of a product

toxic poisonous

transformer a device for stepping up or down the voltage of an alternating current

turbine a machine which produces power when steam, gas, or what is passed over the blades attached to the rotating drive output shaft

turbulence violent or uneven movement of air

undercarriage the supporting framework of a vehicle comprising wheels, axles, suspension, etc.

vapour a gas that can be liquefied by increasing its pressure

viable practical or able to be done, e.g. solar power is viable for most desert regions

wave power a method of generating electricity by using the movement of waves in water

Vocabulary

Air-gap воздушный зазор, искровой промежуток
alignment установка по одной прямой
alternator альтернатор, генератор
analog computer вычислительное устройство непрерывного действия
apart на расстоянии
apart from кроме
applied voltage приложенное напряжение
auxiliaries вспомогательные устройства, оборудование собственных нужд (станций)

Bar magnet полосовой магнит
base цоколь (лампы)
battery charge зарядный агрегат

base line осевая линия
beam power tube мощный лучевой тетрод
blading лопатка (турбины)
boiling heat температура кипения
branch ответвление, фаза (многофазной цепи)
branching-chain reaction разветвленная цепная реакция
break down пробивать, разрывать, разрушать
build up наращивать ток, возбуждать, -ся, развивать напряжение, создавать
bulb колба (лампа), груша, лампа накаливания, шарик (термометра)
button кнопка; петля; шишечка

Carbon dioxide углекислота, углекислый газ
carry a current проводить ток
charger устройство для зарядки конденсаторов
coating обкладка
coherent когерентный; связанный
collapse выгибать, оседать, спадать, -ся, ослабевать; спад; стягиваться
compound engine машина двойного действия (расширения)
compound (wound) generator генератор со смешанным возбуждением, компаунд-генератор
constant current ток с постоянной величиной
constant-current transformer трансформатор постоянной силы тока
control spring устанавливающая пружина
covalent band атомная связь, гомеополярная связь
crankshaft коленчатый вал, кривошип
current transformer трансформатор тока
cut down уменьшить, сократить, снизить отрезок, участок; пороговый импульс
cut off граница, отсечка, пароотсекательный клапан; выключатель (ток)
cycle период
cycle per second герц

Dewater обезвоживать, откачивать воду
dipole диполь (система, образованная двумя расположенными на

некотором расстоянии друг от друга равнопротивоположными электрическими зарядами)
docking стыковка
double-acting двойное действие
driven приводимый в движение, питаемый
dry steam сухой пар

Effective current действующее значение тока, эффективное значение тока
effective resistance действующее сопротивление
end to end конец к концу; непрерывной цепью
energy range область энергий
exert оказывать (воздействие), развивать (о силе, усилии)
exhaust выхлоп; отработать
exhaust steam отработанный, мятый пар
expansion stroke рабочий ход при расширении

Fall off спадать
field coil катушка обмотки возбуждения, катушка электромагнита, индукторная катушка
field magnet индуктор, система электромагнитов возбуждения
field winding обмотка возбуждения
fission расщепление
flatten out выпрямлять, -ся, выравнивать, -ся
flow around обтекать
fluid жидкая или газообразная среда
fractional horse-power мощность менее одной лошадиной силы
fragmentation расщепление, разделение, разрыв
fuel cell топливный элемент
full-line current общий (полный) ток
full wave двухполупериодный

Geodetic геодезический
give off излучать, выделять, испускать
give out (light) излучать
give up уступать, отдавать, отказаться

go into commission вступить в действие
go into operation начать действовать
grid system единая энергетическая система
grid voltage supply подача напряжения на сетку

Half cycle полупериод
half-life (period) (период) полураспада, полувыведения
heat content теплосодержание
heat drop перепад тепла
heating coil нагревательная спираль, катушка
heating element нагревательный прибор, нагревательный элемент
heat of fusion теплота плавления
heavy current сильный ток
heel нижняя часть
high current сильный ток
hold иметь силу, быть справедливым
hollow core полый сердечник
house service meter общий счетчик в доме или квартире

Impressed приложенный (напр., о напряжении)
in line на одной линии
in series последовательно (включенный), в рассечку
in shunt параллельно (включенный)
in step в фазе, синхронно
in suspension во взвешенном состоянии
incident падающий, бомбардирующий
inductive reactance индуктивное сопротивление
inlet pressure давление на входе
input потребляемая мощность, подводимый ток, входящие концы; ввод
intake водоприемник, подвод, головное сооружение водовода
intrinsic, -al внутренний, собственный
intrinsic radiance способность к излучению
isotropic изотропный, изотропический

Laminated слоистый, пластинчатый

laminated core листовой (шихтованный) сердечник
laser оптический квантовый генератор, квантовый усилитель, лазер
latent heat скрытая теплота
lead-in ввод, вводный провод
leading-in wires вводные (в здание провода)
lead-out вывод
line voltage линейное напряжение
live steam острый пар, свежий пар
low current слабый ток

Magneto-hydro-dynamic generator магнитогидродинамический генератор
main circuit магистраль
mains магистраль, распределительные провода
magnetic lines of force магнитные силовые линии
mercury arc rectifier ртутный выпрямитель
micron микрон
moderator замедлитель
mounting схема включения, установка, часть прибора для монтажа
moving blade рабочая лопатка (турбины)
Naked eye невооруженный глаз
negligible пренебрежимый, ничтожно малый
network схема, сеть, многополюсник
next-door близлежащий, ближайший
no-load холостой ход

Offer resistance оказывать сопротивление
offset сдвиг, сдвигать; смещение, смещать; сбивать в сторону
on end стоймя, беспрерывно, подряд
outer space космическое пространство
out of commission в неисправности
out of phase не в фазе, несовпадающий по фазе
output отдаваемая мощность, полезная мощность, производительность, выход

Pass пропускать, пропустить

path контур, путь, линия, цепь, передача
per second per second в секунду в квадрате
photon квант энергии
pick up принимать, воспринимать
pile столб, элемент; ядерный реактор
plate анод, пластинка; металлический лист
plate supply питание анодов
point-contact transistor точечный транзистор
power мощность, энергия, сила; энергетика, степень
power circuit силовая цепь, цепь тока
power engineering энергетика
power factor коэффициент мощности
power grid (единая) энергетическая система
power output выходная мощность
power-plant силовая установка, силовая станция, электростанция
pressure pipe напорный трубопровод
primary первичная обмотка (трансформатора)
pro впереди, прежде
push back оказывать обратное давление
push button нажимная кнопка
put a charge прикладывать заряд, сообщить заряд
put into operation ввести в действие, ввести в эксплуатацию

Range ряд, предел, протяжение, пространство, диапазон, область, участок, радиус действия, шкала
range of temperature температурная шкала
rate of flow мощность потока, сила тока
rate of speeding up нарастание скорости, темп ускорения
rather, than скорее чем; а не
ratio of expansion степень расширения
read отсчитывать, показывать (о приборе)
reference point контрольная точка
resistance factor коэффициент омического сопротивления
resistance wire проволока высокого сопротивления; реостатный провод
resistivity удельное сопротивление, сопротивляемость

resultant (force) равнодействующая (сила)
retarding force сила торможения
run full работать с полной нагрузкой

secondary вторичная обмотка (трансформатора)
send (a current) пропустить, пропускать (ток)
sensible heat теплосодержание, физическая теплота
series (wound) generator генератор с последовательным возбуждением
set up появляться, возникать, наводить, устанавливать; устройство, комплекс
shaped профильный, фасонный, фигурный
«shielding экранирование
shunt (wound)generator генератор с параллельным возбуждением
signal сигнал; выдающийся, знаменательный
slip ring контактное кольцо, токособирательное кольцо
slow down снижать скорость
soft iron ковкое железо, мягкое железо
soft steel малоуглеродистая сталь, мягкая сталь
source of power источник энергетических ресурсов
southbound направляющийся на юг
speck частичка
specific heat удельная теплоемкость
stage ступень, каскад, фаза
steady установившийся (ток, поток)
steel-cored aluminium cable (wire) сталеалюминиевый провод
step down понижать напряжение (трансформатором)
step up повышать напряжение (трансформатором)
stockpile запасы, штабель
stopping distance путь торможения
stream-line линия потока, параллельно-струйный, ламинарный; обтекаемый
strength напряжение, сила
sulphur dioxide двуокись серы, сернистый газ
surface tension поверхностное натяжение

Terminal voltage напряжение на зажимах
therm терм (единица теплоты), калория
thermionic emission термоэлектронная эмиссия
throat дымовой выход
thrust толчок, давление, напор, нажим, упор
top of the diagram вершина диаграммы
torque вращающий момент, пусковой момент
tracer (atom) меченый атом
tractive force сила тяги, тяговое усилие
transistor полупроводниковый триод
transmission shaft вал контрпривода, передаточный вал, промежуточный вал
transient временный, переходный, подвижной
turn out выпускать

U-magnet U-образный магнит
unidirectional одного направления, работающий в одном направлении, направленный в одну сторону
unified power grid единая энергетическая система
unit of current единица силы тока
unit resistance единица сопротивления
unit volume единица объема, объем, равный единице

Vacuum tube электронная лампа
variable speed скорость неравномерного движения, переменная скорость
velocity вектор скорости, векторная скорость
velocity heat скоростной напор
velocity pressure скоростной напор, динамическое давление
velocity staging ступенчатое изменение скорости

Water-fall, or waterfall водопад, перепад уровня
wet steam влажный пар
wiring проводка

X-ray рентгеновский луч

Справочник

чтения математических символов и других условных обозначений, а также наиболее употребительных сокращений в английских технических текстах

1. Дробные числительные (Fractional Numerals)

Простые дроби (Common Fractions)

Числитель выражается количественным числительным (например, two, four, twenty-five и т. д.), а знаменатель — порядковым числительным (например, second, fourth, twenty-fifth и т. д.). Если числитель больше единицы, то знаменатель принимает окончание множественного числа ***s***.

1/2	a half; one half	3/4	1) three-fourths
1/3	a third; one third		2) three quarters
1/4	1) a quarter; one quarter	5/16	five-sixteenths
	2) a fourth; one fourth	9/10	nine-tenths
1/5	a fifth; one fifth	26/38	twenty-six thirty-eighths
1/10	a tenth; one tenth	79/100	seventy-nine hundredths
1/25	a (one) twenty-fifth	125/1000	a (one) hundred and twenty-five thousandths
1/100	a (one) hundredth	1/2	one half (a half)
1/1000	a (one) thousandth	$2^1/_2$	two and a half
1/1374	a (one) thousand three hundred and seventy-fourth	$3^1/_3$	three and a third
2/3	two-thirds	$135^3/_4$	a (one) hundred and thirty-five and three fourths (three quarters)

Десятичные дроби (Decimal Fractions)

В десятичных дробях целое число отделяется от дроби точкой, называемой point. Каждая цифра читается отдельно. Ноль читается любым из трех следующих способов: zero, nought, o [ou]. Ноль целых может совсем не читаться. В Англии и Америке знаки десятичных дробей отделяют точкой, которая может стоять внизу, в середине или вверху строчки.

0.2	1) o [ou] point two 2) nought point two 3) zero point two 4) point two

0.02	1) o [ou] point o [ou] two 2) nought point nought two 3) zero point zero two 4) point nought two 5) point zero two
0.002	1) o [ou] point o [ou] o [ou] two 2) ought point nought nought two 3) zero point zero zero two
0.75	1) nought point seventy-five 2) point seven five
1.1	one point one
1.25	one point two five
63.57	1) sixty-three point five seven 2) six three point five seven
12.707	1) twelve point seven nought seven 2) one two point seven nought seven

2. Отдельные знаки, выражения и уравнения

+ plus
- minus
± plus or minus
: sign of division; colon
= sign of equality

$a = b$ — 1) *a* equals *b*
2) *a* is equal to *b*
3) *a* is *b*

$a \neq b$ — *a* is not equal to *b; a* is not *b*

$a \approx b$ — *a* approximately equals *b*

$a \pm b$	*a* plus or minus *b*
$a > b$	*a* is greater than *b*
$a < b$	*a* is less than *b*
1x1 = 1	once one is one
2x2 = 4	twice two is four
5x5 = 25	five times five (is, equals, is equal to, makes/make) twenty-five
s = v x t	*1) s* equals (is equal to) *v* multiplied by *t* *2) s* equals *v* times *t*
1:2	the ratio of one to two
77:1	the ratio of 77 to 1
16:4 = 4	1) 16 divided by 4 equals 4 2) 16 divided by 4 is 4 3) the ratio of 16 to 4 is 4
20:5 = 16:4	1) the ratio of 20 to 5 equals the ratio of 16 to 4 2) 20 is to 5 as 16 is to 4

3. Проценты

%	- per cent
p. c.	- per cent
pct (амер.)	- per cent
52 %	- fifty-two per cent
3/7 %	1) three sevenths per cent 2) three sevenths of one per cent
l/2 %	1) a half per cent 2) a half of one per cent
0.25 %	1) point two five per cent 2) nought point two five per cent 3) zero point two five of one per cent

4. Именованные числа

2/3 ton	two thirds of a ton
1/2 ton	half a ton
3/4 km	three quarters of a kilometer
. 75 km	point seven five of a kilometer
1.75 kms	one point seven five kilometers
13 lb.; 13 lbs	thirteen pounds
1 1/2 hrs;	1) one and a half hours
1 1/2 hr	2) one (an) hour and a half
60 mi/hr	sixty miles per hour
200 km/4 hr	200 kilometers per 4 hours
6 ft/sec	6 feet per second
1 ft/sec	1 foot per second
75 cu.yd./hr.	75 cubic yards per hour
32 h.p.;	32 horse power
31 m.p.h.	31 miles per hour
45°	forty-five degrees
12'	1) 12 minutes 2) 12 feet
10"	1) 10 seconds 2) 10 inches
68.4° F.	sixty-eight point four degrees Fahrenheit
20° C	twenty degrees Centigrade

5. Сокращения

A.	absolute (temperature)
a-f	audio-frequency
a.c, A. C.	alternating current
BTU, B.T.U.*or* **Btu**	British Thermal Unit
cal.	calorie
C.G.S., c.g.s., cge	centimeter-gram-second
cp, c.p.	candle power
c/s	cycles per second
cu.	cubic
cwt	hundredweight; в Англии центнер равен 50,8 кг. в Америке — 45,36 кг.
db	decibel (единица акустического измерения)

DC,d.c, d-c	direct current
emu	electro-magnetic unit
e.rn.f.	electro-motive force
ev	electron volt
h.p., HP	horse power
hr	hour
i-f.	intermediate frequency
K. cal.	kilo-calorie
kc	kilocycle
kg/cm^2	kilogram per square centimeter
kwa	kilo-watt-ampere
kwh	kilo-watt-hour
kvAh	kilo-volt ampere hour
kv	kilo-volt
1. f.	load factor коэффициент нагрузки; 2) low frequency низкая частота
1. t.	low tension низкое напряжение
m.c.	megacycle мегагерц
m.p.h.	miles per hour
MeV	mega-electron-volt
M.K.S.	metre kilogram second
MVA	mega volt ampere
mil	миль (единица длины, равна одной тысячной дюйма
n	neutron
n. h. p.	nominal horse power номинальная лошадиная сила
o. r.	overload relay реле перегрузки
per cu.ft	per cubic foot
p. f.	power factor коэффициент мощности
p.s.f.	per square foot
r.p.m.	revolutions per minute
r-f	radio frequency
sp.ht.	specific heat
sq.	square
yd.	yard

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Contents

Учебное пособие

Р.М.Нутфулина

Английский язык
для энергетических специальностей

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