ENGLESKI JEZIK ZA INŽINJERE 2

školska godina 2017/2018   fond časova 2+0

VI semestar – stručni kurs engleskog jezika za studente energetike

Predmetni nastavnik: Ivana Mirović, sajt: ivanamirovic.wix.com/pocetna

Konsultacije: sreda 9:30, kabinet 109, blok F

Udžbenik: skripta: Izbor tekstova i vežbanja (I. Mirovic)
može se nabaviti u fotokopirnici FTN-a

PREDISPITNE OBAVEZE: Test (**40 poena**) Može se polagati samo tokom semestra na času.

Da bi mogao polagati test student mora biti prisutan na predavanjima min 3 puta

Proverava se znanje iz sledećih oblasti:

- vokabular (nove reči i stručni termini), kolokacije
- rečenične konstrukcije koje su se pojavljivale i uvežbavale u tekstovima i vežbanjima posle tekstova
- tvorba reči (imenica-pridev, glagol-imenica i sl.)
- snalaženje u nepoznatom tekstu

Da bi izašao na **usmeni** deo ispita student mora imati min 20 poena

ISPIT: maksimalno **60 poena**. Ispit je usmeni. Student izvlači ispitno pitanje (ceduljica sa naslovom jednog od obradjenih tekstova iz skripte), čita tekst i odgovara na pitanja koja postavlja nastavnik

Studenti koji su redovno pohađali nastavu mogu odlučiti da umesto usmenog ispita rade prezentaciju na odabranu temu.

FORMIRANJE KONAČNE OCENE: prema skali koja je prihvaćena na Fakultetu. (50 – 100 poena)

PLAN RADA ZA ENGLESKI ZA INZENJERE 2 2018/19. god.

20. 02. - uvod

27. 02. Man's abilities
mnozina imenica, modalni glagoli, *in spite of…*

06.03. - Electricity in Early Days (from: *Scientific English Practice*)
vokabular, proper names – common nouns, word formation, inversion

13.03. –- Conductors and Conductivity (from: *The Structure of Technical English)*
It is + adjective + to …. structure

20.03. - Reactor Cooling System (from: *The Structure of Technical English*)

27. 03. - Impulse Turbines (from: *The Structure of Technical English*)
Contracted time statement

03. 04. - Introduction to Electric Power Systems (from: *Technical English*)

10.04. – APRILSKI ISPITNI ROK

17. 04. - Conduction and Transmission of Electric Power (from: *Technical English*

24. 04. – Circuit breaker (from: Wikipedia)

08. 05. – Transformers (from: *Technical English*)

15. 05. – Japan's digital grid scheme

22.05. – Origami-Folded Hydrogel Paper Instantly Generates 110 Volts of Electricity
https://spectrum.ieee.org/video/biomedical/devices/origamifolded-hydrogel-paper-instantly-generates-110-volts-of-electricity

29.05. –TEST

05. 06. – Prezentacije, potpisi, pitanja

Engleski jezik za inženjere 2

E1

(g) Since the first men went up in spacecraft, our hopes of space travel (increase).
(h) Since Faraday showed how to produce an electric current with a magnet, electric generators (become) very common.
(i) That scientist (teach) me a lot since I met him.
(j) That scientist (teach) me a lot since 1963.

15 *Man's Abilities*

JAMES HEMMING

The passage below is from the beginning of the Bridge Edition of *Mankind against the Killers*, a book written to describe the scientists' attack on disease and ill-health. Much of Hemming's book deals with the work of the World Health Organization, and in a foreword to the original edition (1955) Dr. Brock Chisholm, who was Director-General of that organization, says that it is the first time 'that a book dealing with health on a world scale has been attempted' for young people. Here the author is describing the advantages that man has over animals.

Man first appeared on earth half a million years ago. Then he was little more than an animal; but early man had several big advantages over the animals. He had a large brain, he had an upright body, he had clever hands; and he had in his brain special groups of nerve cells, not present in animals, that enabled him to invent a language and use it to communicate with his fellow men. This ability to speak was of very great value because it allowed men to share ideas, and to plan together, so that tasks impossible for a single person could be successfully undertaken by intelligent team-work. Speech also enabled ideas to be passed on from generation to generation so that the stock of human knowledge slowly increased.

It was these special advantages that put men far ahead of all other living creatures in the struggle for existence. They can use their intelligence against their difficulties and master them.

Since those far-off times, when he first appeared, man has achieved a great deal. He has used animals, steam, electricity and oil to move himself more and more quickly from place to place. He has overcome rivers and seas with rafts, canoes, boats and ships of endless variety. He mastered darkness, too, first with dim lights and later with brighter and brighter lamps, until he can now make for himself so dazzling a light with an arc-lamp that, like the sun, it is too strong for his naked eyes.

Man found that his own muscles were too weak for the work which he wanted to do; he explored many forms of power—wind, water, steam, electricity—until now he has his hands on the ultimate source of physical energy, the nuclear power which ties together the smallest units from which all matter is made.

From man's earliest days the flight of birds has raised his wonder and desire. Why should he not fly as they did? Then he began to experiment. At last he learnt how to make the right machines to carry him through the air. Now he can fly faster than sound. Already he has plans for conquering space, and a series of experiments has been completed. It will not be long now before man takes a giant step away from this planet and visits the moon, learning what it is like to have no weight to his body, no upward direction and no downward.[1]

Communication also presented man with a problem. Not long ago in history even the most important message took weeks to travel from one country to another in written form or by word of mouth; now a joke on a wireless programme leaps across the world at a speed of 186,000 miles a second. Sight has followed sound: man can now see things happening hundreds of miles away at the very moment when they occur.

Man, always a wanderer, had to overcome the difficulty of adapting himself to different climates. Fortunately, in spite of having no thick skin or warm fur to protect him, he is peculiarly strong compared with other living creatures. Most of them are

[1] Neil Armstrong and Edwin Aldrin of Apollo II landed on the moon on the 16th July, 1969.

unable to live far outside the region that suits them best. Man, however, can go almost everywhere. You will find him living on the plains and up in the hills; he lives in damp areas and in dry; in the forests of the hot regions of the earth, and in snow huts in the Far North.

EXERCISES

COMPREHENSION

1. How long, in the author's opinion, has man lived on the earth?
2. In what ways does a man's brain differ from an animal's brain?
3. What advantage does the ability to speak give to man?
4. How has man used steam and oil to travel?
5. What sort of artificial light is too strong for the naked eye?
6. What is the ultimate source of physical energy?
7. Do ordinary aeroplanes at present fly faster than sound?
8. At what speed do light and wireless waves travel?
9. What can a television receiver do for us?
10. Which can better adapt themselves to different climates, men or animals?

SUMMARISE the passage in about one third of its length.

COMPOSITION

(a) One or two of the great achievements of men.
(b) When trips to the moon are arranged, will you want to go? Why?

LANGUAGE

1. Fill each space with one of the words in its proper form: brain; cell; generation; oil; raft; arc-lamp; nuclear; planet; climate; adapt.
   (a) Many ships are driven by —— instead of by coal.
   (b) Some men crossed part of the Pacific Ocean on a ——, chiefly to show that it was possible.
   (c) The new miner soon —— himself to the conditions in the coal mine.

HX

(d) Peter prefers a dry —— to a damp one because he dislikes rain.
(e) That family has lived in its big house for seven ——; but now the house has to be sold.
(f) The biologist was examining some —— under the microscope.
(g) The dinosaurs, although huge, had very small ——, and so could not think well.
(h) The work on board the ship continued under the fierce light of an ——.
(i) Mars and Jupiter are ——.
(j) —— physicists spend most of their lives thinking about atoms.

2. *Half a million years ago*. A million = 1,000,000. Like *thousand* and *hundred*, it is not put into the plural before a noun or after a number. So we say *five million people* (not *millions*). But when it stands alone, it can take the *-s:*
There are millions and millions of stars in the sky.
In each space put *hundred/s*, *thousand/s* or *million/s*:
(a) There are three —— books in the library.
(b) Five —— students attended the lecture.
(c) He said that there are —— of stars in the universe.
(d) That doctor has —— of patients: probably four hundred.
(e) The aeroplane covered four —— miles in eight hours.
Write the following in words:
(f) 2,000 books. (g) 7,000,000 people. (h) 186,000 miles.
Write the following in figures:
(i) Two hundred and forty-five thousand, seven hundred and ninety-one.
(j) Six million, seven hundred thousand.

3. Put the following into the present simple tense.:
He had a large brain, he had an upright body, he had clever hands; and he had in his brain special groups of nerve cells, not present in animals, that enabled him to invent a language. This ability to speak was of very great value because it allowed men to share ideas.

4. Change the following into questions:

(a) Speech enabled ideas to be passed on.
(b) The stock of human knowledge slowly increased.
(c) Men can use their intelligence against their difficulties.
(d) From man's earliest days, the flight of birds has raised his wonder and desire.
(e) Man had to overcome the difficulty of adapting himself to different climates.

5. *In spite of having no thick skin . . .*
The phrase *In spite of* is followed by a noun or pronoun. We say, for example, *In spite of the rain, we played football.* (= Although it rained, . . .) The verbal noun of *To have* is *Having*, and this is the part used after the phrase.
Write sentences containing the following:
(a) In spite of our singing. (b) In spite of their arriving in the middle of the performance. (c) In spite of his eating too much dinner. (d) In spite of my failing to finish the work. (e) In spite of walking twenty miles, we . . .

6. Write original sentences containing the following:
(a) It will not be long before. (b) The source of. (c) It takes months. (d) Hot regions. (e) Nerve cells.

7. *Man had to overcome the difficulty. Have to* = must. It may be used in any tense.
Complete the following sentences:
(a) If we set out late tomorrow, we (have to) take a taxi.
(b) When he broke the retort, the scientist (have to) get another from the cupboard.
(c) If I went to live in the tropics, I (have to) buy some thin clothes. But I shall probably not go.
(d) Will you have to work hard when . . . ?
(e) Would you have had to pay the fare if you . . . ?

19 *Electricity in Early Days*

GEOFFREY GERARD, F.R.S.E., A.M.I.E.E.

A short outline of the early history of electricity is given in Geoffrey
Gerard's book *The Young Man's Guide to Electrical Engineering* (1962),
and in the piece given below the author is describing the work and
experiments of some of those who made the first valuable discoveries
in this science. The author has written other books on the uses of electri-
city; and he had the help of large electrical engineering companies, the
Institute of Electrical Engineers, and the Central Electricity Generating
Board, in writing this book. He is a Fellow of the Royal Society of
Edinburgh.

The next step was the invention of the Leyden jar, which
appeared somewhere about the middle of the eighteenth century.
The Leyden jar is a kind of condenser. An early type consisted
merely of a bottle containing water (or alcohol or mercury) with
a long nail dipping into the liquid.

The use of the Leyden jar was that it enabled electricity to be
stored. True, it was not of much practical value, but at least it
caused plenty of amusement. We read accounts of people experi-
menting with electric shocks from Leyden jars. Indeed, on one
occasion, a whole company of monks formed a line nine hundred
feet long with wires making contact from man to man. They
certainly experienced more than they expected; for when the ends
of the wires were joined to a battery of charged Leyden jars, all
the monks leaped into the air.

An unwise experiment which is often mentioned is Benjamin
Franklin's famous kite in a thunderstorm. Franklin came off
rather well[1] in this. Not only did he show that lightning behaves
in the same way as the sparks from an electric machine, but also
he escaped being electrocuted.

An important advance was the invention of the simple electric

[1] Came off well: Was lucky.

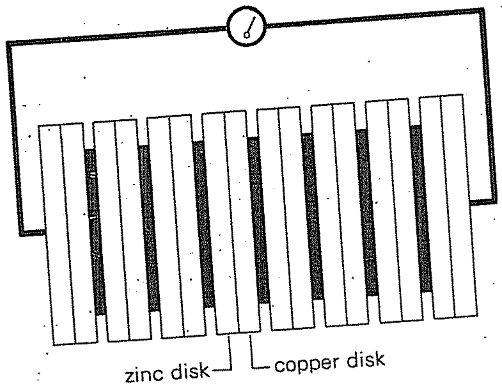
cell. This came about as the result of the work of two men,
Galvani and Volta. The Italian, Luigi Galvani, discovered by
chance that electricity from a Leyden jar or an electric machine
would cause the legs of a dead frog to move. This puzzled
Galvani, so he started experimenting in order to try to discover
the cause.

He discovered that if two pieces of unlike metal, say copper and
zinc, were placed on a nerve and a muscle, and then brought
into contact with each other, the dead frog could be made to
move. Galvani realized that it was the action of two different
metals in the frog's leg that produced the electricity.

His discovery greatly interested one of his countrymen, Volta,
who carried out many experiments with metals and chemicals.
Volta succeeded in producing a simple form of cell which is the
parent of modern batteries. The invention of Volta's cell is
important, because it meant that for the first time it was possible
to maintain an electric current for a long period. This was
unlike the Leyden jar, which merely gave a sudden rush of
current.

In 1819 the Danish scientist Oersted, like many other great
pioneers,[1] found out accidentally that a relationship exists
between electricity and magnetism. By chance a wire connected
to a battery was moved near a compass needle on the table.

[1] Pioneer: One who goes in front and prepares the way.



Volta's electric cell

Oersted was astonished to notice that when current passed through the wire the compass needle was moved. It no longer pointed to the north. Oersted's discovery interested the French scientist Ampere, and as a result of patient experimenting he succeeded in fixing the laws which govern electro-magnetic effects.

We now come to the man whose discoveries made modern electrical engineering possible. He was Michael Faraday, born in 1791 in Yorkshire. Faraday discovered that an electric current will flow in a coil of wire when the coil is rotated between the poles of a magnet. Basically all electric generators in power stations today work on this principle.

EXERCISES

COMPREHENSION

1. Describe one early type of Leyden jar.
2. What could a Leyden jar be used for?
3. What happened to the monks?
4. Why was Benjamin Franklin very lucky with his kite?
5. What did Galvani discover about the frog and about two pieces of unlike metal?
6. What did Volta construct?
7. Who discovered the relationship between electricity and magnetism?
8. In which century was Faraday born? In which century was his life's work done?
9. If a coil is moved near a magnet, what happens?
10. Who discovered the principle on which all electric generators work?

SUMMARISE the last five paragraphs in about 120 words.

COMPOSITION

(a) The value of having electric current laid on in a house.
(b) Magnets.

LANGUAGE

1. Fill each space with a word from the list in its right form:

condenser; mercury; alcohol; contact; battery; electrocute; chemical; pioneer; magnetism; coil.

(a) The —— in the iron will almost disappear when the current ceases.
(b) The radio set did not work properly because one of the valves was loose, and the —— between one pin and the socket was unsatisfactory.
(c) —— are often made of sheets of metal with some insulating substance between them.
(d) The boy was standing in water when he touched the electric wire; so he was immediately ——.
(e) Baird was one of the —— in the search for some way of making a television set.
(f) —— is often useful to a scientist, but not so useful when it is drunk.
(g) Tom's car has a —— of six cells; it gives twelve volts.
(h) The electrician connected the ends of the —— to the electric mains.
(i) Several jars full of —— stood on the laboratory table. They were all compounds.
(j) The thermometer contains —— which expands in hot weather.

2. The italicised words below are electrical terms formed from the names of pioneers. Give the names of these men, and give their nationality:

(a) The pressure is two hundred and thirty *volts*. (b) The scientist was using a *galvanometer*. (c) A current of 500 *amperes* would melt the wire. (d) The value of this condenser is ·0001 *microfarad*. (Note: *Micro-* (Greek) = *small*, and often means *one-millionth* in science.) (e) Measure it with an *ammeter*.

Explain:

(f) 6 amps. (g) ·0001 mfd. (h) One microvolt. (i) A voltmeter. (j) Ten micro-amperes.

3. The following occur in the passage. Write original sentences containing them:

(a) consist of; (b) an electric shock; (c) contact; (d) charged; (e) lightning; (f) sparks; (g) came about; (h) compass; (i) rotate; (j) generator.

4. Insert the correct prepositions in the spaces. The passage will probably help you:
   (a) The first atom bomb exploded —— the middle —— the twentieth century.
   (b) He was experimenting —— some rods which dipped —— an acid.
   (c) The invention —— the generator was —— great value —— the world.
   (d) What does a battery consist ——?
   (e) They went —— house —— house, selling cloth.
   (f) Galileo succeeded —— observing the moon through a telescope.
   (g) Put this wire in contact —— the terminal on the battery.
   (h) —— chance the wire was connected —— a battery.
   (i) The wires appeared to be joined —— the terminals of a motor.
   (j) —— the first time it was possible to use a current.

5. *Not only did he show . . . , but also he . . .*
   When we start a clause with *Not only*, and several other adverbs, we must put the verb before the subject as in a question.
   Complete the following:
   (a) Not only does Peter know Italian, but he also . . .
   (b) Not only was the frog's leg moved when . . . , but Galvani realized that . . .
   (c) Hardly had Tom switched on the light when . . .
   (d) No sooner had the professor started the motor than . . .
   (e) Not only (men go) up in rockets, but they also . . .

6. *It enabled electricity to be stored. Enable* = make able, make possible. The prefix *en-* forms verbs. The suffix *-en* also forms verbs. The suffixes *-fy* and *-ise* (*-ize*) also form verbs.
   Form verbs from the following:
   (a) wide; (b) short; (c) red; (d) black; (e) force; (f) sure; (g) able; (h) close; (i) apology; (j) liquid; (k) solid; (l) large; (m) circle; (n) camp; (o) length; ~~(p) strength~~; (q) special;

en camp

(r) pure; (s) danger; (t) dark.
   (Note: Scholars prefer the ending *-ize* to the ending *-ise* in most cases; but sometimes *-ize* cannot be used, and it is best for the student to keep always to *-ise*.)

7. *Unwise* is the opposite of *wise*. Give five other words using the prefix *un-*, and five starting with *in-*.

Section 19

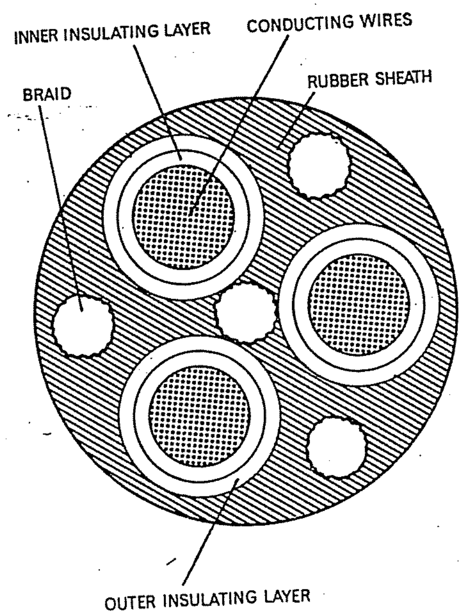
Reading: Conductors and Conductivity

It is usual to **consider** electric current **as** a flow of electrons from one point to another through a medium, or even through a vacuum. If the electron flow takes place in a vacuum, as in the case of electronic valves, the electrons will travel at considerable speeds, since little resistance is offered by the medium, and fewer impacts will occur between the electrons. If the medium is a solid – in which case the electrons are more tightly packed – the electron flow will be slower.

All substances may be **classified** electrically **as** conductors or insulators, according to the degree of resistance which the medium offers to the flow of current. Most liquids, particularly solutions in liquids, are good conductors. Most gases at normal temperature and pressure are good insulators, but gases maintained at low pressure in a sealed tube allow a flow of current to take place as a result of ionisation of the gas molecules. Solids vary greatly in resistance, some being very good conductors, while others are so resistant that they are **referred to as** insulators. Electric current is normally transmitted along annealed copper wire.

The resistance of any material to the flow of current is affected by a number of factors, such as the length and cross-section of the conductor, and by its resistivity, which is a specific property of the material at a specific temperature. The temperature therefore also has some effect on the resistance of a material: in most cases, an increase in temperature causes an increase in resistance. With certain metals, such as copper or iron, the change in resistance which attends on changes in temperature is relatively large – a fact which is utilised in the resistance thermometer, in which *it is possible to* measure temperature changes, as in the windings of an electric motor, for instance, by the change in resistance.

Some materials have a very high resistance, and **as such** they can be **used as** insulators to prevent the leakage of current. Among these materials are asbestos, celluloid, porcelain, cotton and rubber, and recently a number of new materials have been developed, including synthetic textiles such as nylon, and synthetic resins such as vinyl resins. The resistivity of most insulators and synthetic resins decreases with an increase in temperature, for which reason the temperatures in insulated conductors must be kept reasonably low. A breakdown of insulation may occur under the application of very high voltages, and *it is necessary to* know the dielectric strength of any insulating material. Some materials, such



Cross-section of electric cable

as cotton, which is often **used as** insulation, are liable to absorb moisture, and this will adversely affect their insulating properties. Rubber, which is a standard insulating material, is liable to deteriorate under sunlight, and *it is therefore advisable* to protect it with some weatherproof material.

WORD STUDY

Affect (v); *Effect* (n)

1. The temperature of the conductor
2. The presence of carbon in the iron
3. Machine vibration

affects / *influences* / *has an effect on* — its resistance to current. / its behaviour. / the surface finish of the work.

4. The poor quality of the goods *adversely affected* / *had an adverse effect on* the sales.
5. The high quality of the goods *favourably affected* / *had a beneficial effect on* the sales.

6. The *effect of* the carbon in the iron *is to* change its behaviour.
7. The *effect of* vibration in the machine *is to* produce a poorer surface finish.
8. The *effect of* increased temperature in a conductor *is to* increase its resistance.

Deteriorate – Improve (get worse, get better)

1. Coal is likely to
2. Rubber will slowly
3. The performance of the engine will
4. The economic position of the country will

} *deteriorate* {
- if stored for long periods in the open.
- when exposed to the sunlight.
- if serious leakages of steam occur.
- unless there is a rapid increase in production.

5. The efficiency of the engine was
6. The performance of the jet is

} *improved* {
- by fitting a turbo-compressor.
- by using after-burners.

Medium

1. The temperature of the
2. Induction motors operate through the
3. Coal gas was the chief
4. Any working
5. Steam is used as the working

} *medium* {
- through which heat is transmitted by radiation is not raised.
- of a moving magnetic field.
- for lighting in large towns.
- can be used with this cycle.
- in these turbines.

Specific – Specify

a) The *specific* {
- weight of an aero-engine is the weight in pounds for every pound of thrust.
- gravity of a substance is the ratio between the weight of 1 c.c. of the substance and the weight of 1 c.c. of water.
- heat of a substance is the number of calories needed to raise 1 gram of the substance by 1° C.
- heats of most substances vary with their temperature.

b) = definite and detailed

The engineer was given *specific* instructions on what to do.
The terms of employment must be clearly *specified* in the contract.
The exact dimensions and tolerances should be *specified* by the customer.
The *specification* should include all the information required by the contractors to carry out the work properly.

PATTERNS

1. It is + *Adjective* + to

This pattern, and similar ones which we shall look at in the following Sections, are an essential feature of the scientific style. By using this type of introduction to a sentence, we avoid using the personal form. Instead of saying:

We can measure temperature changes

the scientist can say:

It is possible to measure temperature changes

We have therefore an alternative to the normal passive statement:

Temperature changes can be measured.

The important words which can be used in this pattern are:

It	is was seems appears proves becomes	easy possible necessary essential advisable preferable useful instructive desirable advantageous practicable common usual	(difficult) (impossible) (unnecessary) (inadvisable) (useless) (undesirable) (disadvantageous) (impracticable) (uncommon) (unusual)	to	do something.

EXERCISE

Change these statements into the pattern shown above:

1. We do not want to allow cold water to enter the boiler.
2. There is no difficulty in pumping out the water from the condenser.
3. We must eliminate as far as possible eddy currents in the magnet core.
4. We normally connect the generator to a pair of feeding points.
5. The whole of the compression cannot practicably be carried out in one cylinder.
6. We prefer to obtain higher pressures by having more compression stages.
7. There is some advantage in working at lower temperatures.
8. Where there is a limited supply of water, one should not use a jet condenser.
9. We are now in a position to produce fissile material artificially.
10. We often use two separate condensers to do this.
11. You would be well advised to measure the dimensions of your work after each cut.
12. A film of lubricant must be maintained over the wire during manufacture.
13. The metal should be tempered after it has been quenched.
14. We can reduce the amount of friction by using rolling bearings.
15. We shall learn a lot by looking at the accompanying diagram.

2. As

In Sections 9 and 11, we noticed the use of *as* in time-statements, and in Section 12, we noticed its use in cause-statements.
Now in this section and the following ones, we shall look at some of the other uses of this important and difficult word.

a) *Known as*, etc.

1. This type of motor is *known* / *referred to* *as* an induction motor.
2. The efficiency of the engine is *expressed as* a percentage of the ideal efficiency.
3. Cylinder clearance is *defined as* the ratio of clearance volume to swept volume.
4. Electric current may be *considered* / *regarded* / *looked on* / *seen* *as* (being) a flow of electrons through a medium.
5. These materials may be *classified as* conductors.
6. The conductivity of copper wire is *taken* / *accepted* *as* (being) the standard for all measurements of conductivity.
7. The limestone in the furnace *serves* / *acts* *as* a flux to assist the melting.
8. A hollow tube is often *used* / *employed* *as* a conductor of current.

b) = *In the form of*

1. The condensate is returned to the boiler	*as*	feed-water.
2. The steam is cooled and condenses		a film of water.
3. The carbon in cast iron is present partly		free graphite.

c) *As + Past Participle* (with roughly the same meaning)

Natural uranium, *as* obtained from the refining plants, is a solid.
The uranium, *as* used in the reactor, is in the form of a thin rod.
The bridge, *as* originally planned, would have been too expensive.

d) *As such*

1. The earth is a conductor of electricity and	*as such*	may form part of an electrical circuit.
2. A simple governor is dependent on gravity;		it must be kept vertical.
3. This fuel has a high octane number and		it is less likely to detonate.

EXERCISE

Complete these statements, as shown above.

1. This is the main London–Manchester road, and ...... it carries a great deal of traffic.
2. The specific weight of a gas turbine ...... pounds weight per pound of thrust.
3. When the reactor is moderated by water, this water ...... the coolant also.
4. The petrol is mixed with air and injected into the cylinder ...... a spray.
5. The slip of the rotor usually ...... (express) ...... a percentage of the speed of rotation of the magnetic field.
6. The tailstock or dead centre on the lathe is stationary, and ...... it is liable to become heated.
7. Metals composed mainly of tin ...... tin-base metals.
8. A particle of gamma radiation ...... (sometimes) ...... a photon.
9. The work ...... projected will take ten years to complete.
10. The energy from nuclear fission is taken out of the reactor ...... heat.
11. The drag force acting on the fluid can be ...... being limited to the boundary layer close to the walls.
12. Increasing the moisture content ...... (usually) ...... humidification.
13. The vehicle, ... shown in the illustration, costs £2000.
14. The simple diode ...... (use) ...... a low-power rectifier.
15. This man is a skilled lathe-operator; ...... he is entitled to higher rates of pay.

3. Examples

It is sometimes possible to use *as* and *like* when we are giving examples. But the commonest and best expression is *such as*, used as in these examples.

1. Some substances,	*such as*	tungsten, emit electrons when heated in a vacuum.
2. Projects,		this one, require a great deal of planning.

3. *Such*	substances	*as*	tungsten emit electrons when heated in a vacuum.
4.	projects		this one require a great deal of planning.

5. The metal must be able to withstand very high temperatures	*such as* (= of the kind which)	are encountered in the high pressure compressor.
6. Soldering is one way of making joints in wire		occur in electrical work.

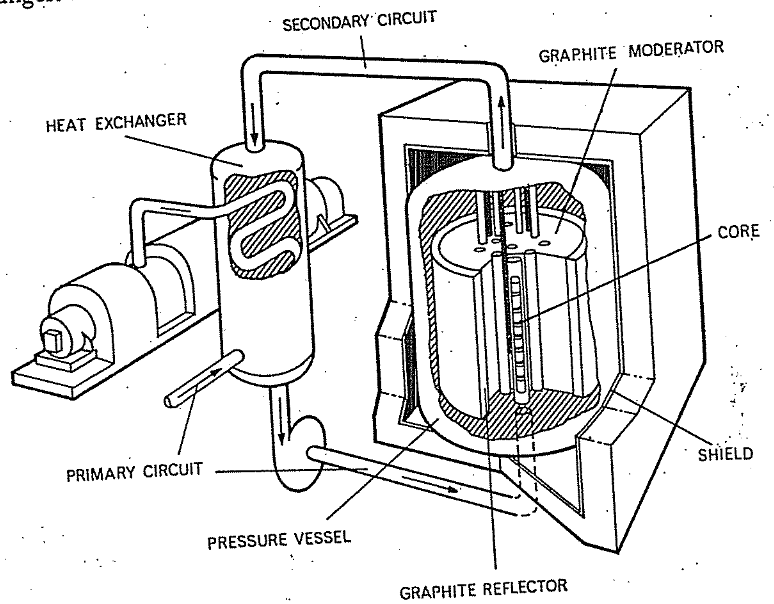
7. The temperatures at the turbine blades are as high as 600° C.	*Such*	temperatures (*as* these) need special materials.
8. Some materials offer a very great resistance to the flow of current.		materials are called insulators.
9. The rotor may have a voltage induced in it by the moving magnetic field.		a motor is known as an induction motor.

Section 18

Reading: Reactor Cooling System

Various types of reactor *have been designed* and constructed for a number of different purposes, such as the production of fissile material, the production of radio-isotopes, and the generation of electrical power. In the case of reactors designed to produce power, it is essential to devise some method of transferring the heat generated in the reactor core to a heat engine, where it can be converted into electrical power. It is in any case necessary to provide some efficient cooling system, so that the temperatures in the core should not exceed the safe limit of about 600° C.

The cooling system adopted in a reactor depends on whether the moderator is liquid or solid. In the case of a liquid-moderated reactor, the moderator itself acts as a coolant, and can be circulated out of the core and through a heat exchanger. But in cases where the moderator is a solid (normally graphite), a



Reactor cooling system

separate cooling system must be provided. The coolant is circulated through the annular spaces between the fuel elements and the moderator, absorbing heat as it passes, and the heat **so absorbed** is conveyed out of the core to the heat exchanger. Very large quantities of heat are generated by fission, and in order that these may be rapidly dissipated, a large volume of coolant is required. It is therefore frequently pressurised, especially where a gaseous coolant is used, to increase its density. A number of different coolants *have been employed*, including water, carbon dioxide and liquid metals. It is essential that the fluid **so used** should have good heat-removal properties, and also a low neutron absorption. To pump such a large quantity of coolant through the core, large pumps are needed, and the power supply for these pumps is taken from the power output of the reactor. Since the power **thus consumed** diminishes the total useful output of the reactor, it should be kept as low as possible.

Coolant which *has been passed* through the reactor will be in some degree contaminated by radiation, and cannot therefore be allowed to come into contact with the turbo-generators. The coolant is circulated in a closed primary circuit, and its heat content is transferred to a secondary circuit through a heat exchanger. In some reactors a liquid-metal coolant is used, and it is likely to become heavily irradiated. In such cases, both the primary circuit and the heat exchanger are therefore included within the biological shield. The working fluid in the secondary circuit is fed into turbo-generators, where its energy is converted into electrical power. Reactors *have recently been built* which are capable of generating up to several hundred megawatts.

WORD STUDY

Core (= heart, or centre)

The *core* of an apple. The *core* of a problem.
When a steel bar is cooled, the case will cool before the *core* does.
The iron bar at the centre of a solenoid is called the *core*.
Cables can be made of aluminium with a thin *core* of steel wire.
When complicated castings are made, a *core* moulded from dried sand is used to form the hollow centre of the casting.
The coolant removes heat from the reactor *core*.

Contaminate, Pollute (= make impure)

1. Exhaust gases from boilers, vehicles, etc., cause air *pollution* in cities.
2. Rivers are *polluted* by the effluent from sewers and drains.

3. High-pressure steam may be	*contaminated*	by the material of the vessel which contains it.
4. Air in a cylinder may be		by leaking lubricant.
5. Condensate will be		if it mixes with impure cooling water.
6. Spots will appear on zinc crystals when they are		by iron.
7. Objects and people may be		by an escape of radiation.

In-, Out-, Through-

The air *intake* or *intake* manifold of an engine is the passage through which air is taken into the cylinders.
The *inlet* and *outlet* valves let the air in and out of the cylinder.
The power *input* is the power which must be fed into a machine to make it work.
The power *output* is the power delivered or sent out by an engine.
The heat *output* is the amount of heat which can be delivered.
The factory *output* is the number of items produced by a factory.
The *throughput* is the amount of oil, water, gas, etc. which is pumped through a pipeline.

PATTERNS

1. Uses of the Perfect Tense

The perfect tense is not nearly so common as the Present and the Past Tenses, but its main uses should be noted carefully.
The *passive* form is, as usual, more common than the *active* form.

i.e. *work has been started* rather than:
they have started work.

a) In structures which describe an event *before the present* but at *no* specific or definite time.

Work *has been started* on the new system of motorways.
Research *has shown* a probable connection between smoking and lung cancer.

b) In structures which describe an event or series of events happening *continuously* or *repeatedly up to the present.*

Various types of reactor *have been designed* for different purposes.
Engineers *have encountered* many problems with this material.

c) In structures associated with words like *already, not yet, for, since.*

Work on the motorway *has not been started yet.*
Work on the motorway *has already been completed.*
Work on the motorway *has been going on since* 1958.
Test borings *so far have indicated* the presence of large oil deposits.

d) In structures associated with the words *just, recently* and *lately.*

The company *has just developed* a new type of aircraft.
Recent research has shown a connection between smoking and cancer.
Work on the motorway *has recently been held up* owing to bad weather.

EXERCISE

Practise this pattern with the following statements:

1. The presence of large coal deposits ...... (*prove*) by preliminary surveys.
2. The whole area ...... (already; *photograph*) from the air.
3. Difficulties with the fuel injection system ...... largely (*overcome*).
4. These experiments ...... (*have*) very interesting results.
5. Work ...... (just; *begin*) on two 500 Mw nuclear power stations.
6. Several of the workers who were exposed to radiation ...... since (*die*).
7. The steam which ...... (*exhaust*) from the turbine is then condensed.
8. Studies ...... (*make*) over a long period to determine the best type of engine lubricating oil.
9. The government ...... (recently; *invite*) tenders for the construction of the coffer dam.
10. The engine, which ...... (*design*) primarily for aircraft, may also prove suitable for other purposes.
11. After these coal seams ...... (*exhaust*), the coal mine will be closed down.
12. Flying tests ...... (not yet; *complete*) on the prototype machine.
13. Considerable care ...... (*take*) to ensure the greatest reliability in performance.
14. The company ...... (*spend*) a great deal of money on research in recent years.
15. The plastics industry ...... (*expand*) enormously since the end of the war.
16. After the fuel elements ...... (*use*) in the reactor, they are removed and cooled.
17. This type of valve ...... (*prove*) very satisfactory over a great many years.
18. All the designs submitted ...... carefully (*consider*), but none of them ...... (*find*) adequate, and no contract ...... (*award*).
19. Once the metal ...... (*heat*) beyond the critical temperature, it is allowed to cool slowly.
20. The department, which ...... (*found*) in 1945, ... (*expand*) every year since then, and ...... (*do*) some very useful work.
21. If no allowance ...... (*make*) for expansion of the metal, severe stresses will be set up in it.
22. The company ...... (*suffer*) a severe financial loss over the past year.
23. Plans ...... (*make*) to increase production immediately, and this ...... (*necessitate*) taking on a number of extra craftsmen.
24. Steam which ...... (*condense*) in the condenser can be passed back to the boiler for re-use as feed water.
25. The first steam engine ...... (*build*) about two hundred years ago, and since that time steam ...... (*become*) the most important single source of power that man ...... (ever; *know*).

2. Manner (2)

In Section 12, we noticed the contraction of the passive relative:

The petrol mixes with a stream of *air blown* over it.
There is a throttle *valve operated* by the accelerator.

Now we often find the same structure enlarged by *so* or *thus*.

The houses are made of wood. Houses *so constructed* are much cheaper to build. (= houses which are constructed *in this way*)
Shareholders' dividends will be cut, and the money *thus saved* will be used for plant modernisation. (= the money which is saved *in this manner*)

So constructed and *thus saved* obviously refer back to the information given just before. *So* and *thus* are placed before the participle. *In this way* and *in this manner* are placed after it.

EXERCISE

Complete these statements using this contraction-pattern.

1. Dopes such as lead tetra-ethyl are sometimes added to the petrol. Petrol ...... (*treat*) is less liable to detonation.
2. Secondary air is mixed with the products of combustion, and the gases ...... (*cool*) then enter the turbine.
3. Fully automated machinery has been introduced, and the increase in production ...... (*achieve*) has been very satisfactory.
4. High-pressure air under the wings escapes round the wing-tips to the low-pressure region above, and the vortex ...... (*form*) is a source of drag.
5. The heat energy from the reactor is used to drive a turbine, and the power ...... (*generate*) is fed into the national grid.
6. The plates to be welded are placed between the electrodes, across which a current is passed. The heat ...... (*produce*) is sufficient to weld the plates together.
7. Alloy steels are quenched from a temperature of about 800° C, and then tempered. Steels ...... (*treat*) are very hard, and are used for making dies.
8. As the rotational speed increases, the governor arms are raised, and the slight movement ...... (*produce*) is communicated to the steam throttle through a relay.
9. The exhaust gases are ejected from the jet-pipe, and the thrust ...... (*develop*) drives the aircraft through the air.
10. Unless care is taken, steam will escape round the tips of the blades, and the losses ...... (*cause*) will reduce the turbine efficiency.

3. Cases

The word *case* and the phrases associated with it are very important.
In Section 16, we noticed two *case*-phrases connected with *eventuality*:

in case of fire . . .
in case it rains, I shall take my umbrella.

The word *case* has the general meaning of *a particular example or instance* as you can see from the following passages:

---

a) The doctor found one or two interesting *cases* of heart disease among the patients he examined. *In the case of* one patient, several heart attacks had already occurred, but *the other cases* were not so serious. This disease is *in any case* common among elderly people, but *in certain cases* quite young people may also suffer from it. *In such cases* there is often a history of heart disease in the family, and *in a few cases* a childhood illness may have been responsible.

b) The samples were all examined when they were unloaded. *In some cases* the packaging was inadequate, while *in several cases* the samples were not packed at all. *In every case where* the packaging was faulty, the samples were spoiled, and *in no case* were they properly labelled. This is probably *a case of* inefficiency on the part of the manufacturers, *in which case* the matter should be brought to their attention.

Note: 1. *in any case* has the idiomatic meaning of *anyway*.
2. *in no case* requires inversion of the subject and verb.
3. the use of *where* after *case*, or even instead of *case*:
(In *cases*) *where* the goods were found to be faulty, they were returned to the manufacturers.
4. *case* constructions such as the above should be used sparingly; not so frequently as in the examples or in the exercise which follows.

EXERCISE

Complete this passage with a suitable 'case' phrase.

The radioactive half-life of different isotopes varies enormously. ...... polonium 216, it is only a fraction of a second, while ...... such materials as uranium 238 or 235, it is several thousand million years. The penetrative power of the radiation from these unstable isotopes depends on the type of radiation. ...... gamma rays, the penetrative power is very great, and a heavy protective shield is required. There have been ...... workers have been exposed to dangerous radiation doses, and ...... severe illness or even death has resulted. Since these radioactive isotopes present such severe health hazards, they must be treated with great care. ...... may they be handled directly. Mechanical manipulators and conveyors must be used ...... It is obviously necessary ...... to view the irradiation process while it is going on, and ...... heavy shielding windows can be used, ... as much as three feet thick. ...... a maze and mirror system may be used, enabling the operators to view the process in safety. Great care must also be taken with the disposal of radioactive waste, especially ...... the level of radioactivity is high. ...... a nuclear reactor, the disposal of waste becomes extremely important.

Section 10

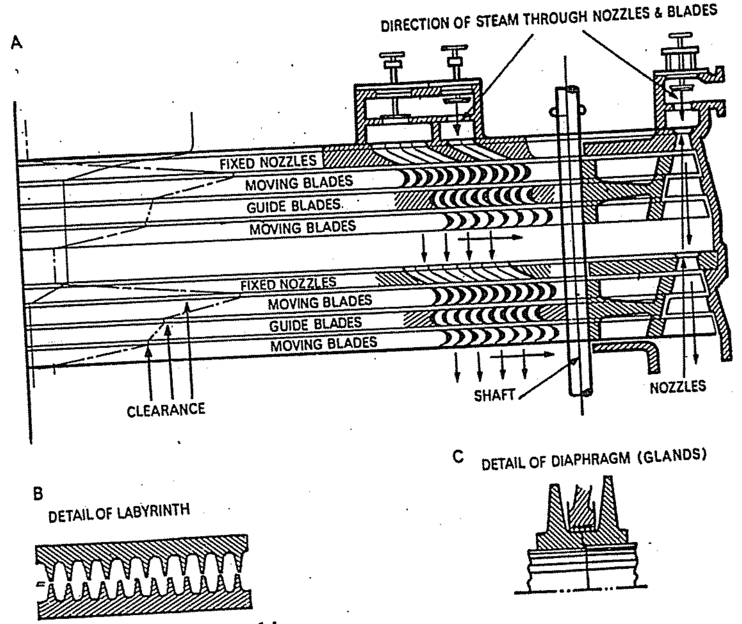
Reading: Impulse Turbines

In an impulse turbine steam is admitted through a nozzle and directed against one or more rows of blades. *Prior to passing* through this nozzle, the steam is at high pressure but low velocity. The nozzle normally consists of a convergent and divergent section. In the former, the steam suffers a drop in pressure, but its velocity is increased. The function of the divergent section is to reduce to a minimum the tendency of the fluid to turbulence, and thus to ensure that the fluid flow is as smooth as possible.

On emerging from the nozzle at its maximum velocity, the steam impinges on the row of moving blades which project radially from the turbine shaft. In this axial-flow type of turbine, the steam flow is along the axis of rotation of the shaft, and therefore the blades radiate outwards from the shaft. *On entering* the blades, which are set at a definite angle to the steam flow, the steam is deflected from its original path. *In being deflected*, it exerts an impulsive force on the blades, which causes them to rotate. *While passing* over the blades, the steam suffers a slight reduction in velocity through friction. In a simple turbine, it is then passed out into the atmosphere, or to a condenser, where it is condensed and led back to the boiler.

However, *after leaving* the blades of the turbine, the steam still possesses a considerable velocity, and this may be utilised in another type of turbine by passing it through a series of two or more turbine wheels. This is known as velocity-compounding. *On passing* through the first row of moving blades, the steam encounters a row of stationary blades which deflect the steam on to a second row of moving blades, and so on. Each time part of the kinetic energy of the steam is lost through friction, and therefore the velocity of the steam is progressively reduced. In order to compensate for this, the blades in each successive row are made progressively larger in cross-section, and their pitch is increased. In this way, a larger proportion of the kinetic energy of the steam can be utilised than in the simple turbine.

Another type of turbine in common use is known as the pressure-compounded turbine. It incorporates several rows of blades, but each one is enclosed between diaphragms to form a separate pressure stage. *After passing* through the first set of blades, the steam is directed through nozzles set in the succeeding diaphragm, and impinges on the following row of blades.



Cross-section of impulse turbine

WORD STUDY

Tend, Apt, Inclined

1. A person
2. Wet steam
3. Cast-iron
4. Turbulence

} *tends to* / *is apt to* / *is inclined to* { put on weight when he eats too much. / erode the blades of a turbine. / fracture under excessive tension. / dissipate the kinetic energy of the steam.

5. Leaks
6. Steam pockets

{ *tend to* / *are apt to* / *are inclined to* } develop around the tips of the turbine blades. / form in the water tubes.

7. There is a *tendency for* { leaks to develop round the tips of the blades. / cast-iron to fracture under excessive tension.

8. The present *tendency is* to use pulverised fuels in large boilers.

Impinge on, Encounter

1. The flames from the furnace should not *impinge on* the joints. (= strike)
2. On entering the turbine, the steam *impinges on* the rotating blades.
3. The beam of accelerated protons *impinges on* a beryllium target.
4. On entering the turbine, the steam *encounters* a row of fixed blades. (= meet)

Deflect, Refract (bend); *Reflect* (bend back)

1. A ray of light entering water at an angle is *refracted* / *deflected* at the surface.
2. A ray of light passing through the glass of a mirror is *reflected* by the silver.

3. A billiard ball which strikes another ball is
4. Steam which impinges on the turbine blades is
5. A nearby piece of iron causes a compass needle to be

} *deflected* { from its path. / from its course. / from north.

Diverge, Converge

1. Railway lines seem to
2. All roads tend to
3. The sides of the nozzle

} *converge* { as they go away from the observer. / as they approach a large city. / towards the throat.

4. Railway lines seem to
5. All roads tend to
6. The sides of the nozzle

} *diverge* { as they approach the observer. / as they go away from a large city. / as they go away from the throat.

PATTERNS

1. Contracted Time Statements (1)

In the previous section, we practised time statements in which the subjects of both parts of the statement were the same.

e.g. Before *the steam* enters the nozzle, *it* is at very high pressure.
Before *it* enters the nozzle, *the steam* is at very high pressure.

These time statements are very often shortened or contracted to:

Before entering the nozzle, the steam is at very high pressure.

Here are the different possibilities of this structure:

Before / *Prior to* } entering the nozzle, the steam is at high pressure. { = *before* it enters.

When / *While* / *In* } passing through the blades, the steam is deflected. { = *while* it is passing through.

After / *On* } leaving the blades, the steam passes out to the atmosphere. { = *after* it leaves.

EXERCISE

Change these statements in the same way.

1. Before it mixes with the products of combustion, the air is pre-heated.
2. As the piston rises, it carries the exhaust gas upwards.
3. The aircraft exploded as it was landing.

4. After the gases pass through the boiler, they are still very hot.
5. As the shaft rotates, it splashes oil up into the bearings.
6. When the metal surfaces reach welding heat, they are pressed together.
7. As the rivet cools, it contracts.
8. When bearings rotate at high speeds, they generate frictional heat.
9. Before it enters the furnace, the fuel is pulverised.
10. When it leaves the furnace, the molten metal is channelled into moulds.
11. While the fuel is travelling along the conveyor chain, it burns.
12. Before it becomes molten, the metal is in a plastic state.
13. The structure of the metal begins to change as soon as it exceeds the critical temperature.
14. The hot gases pass up the flue to the chimney after they transmit their heat to the boiler water.
15. The gas may be compressed before it is circulated through the mains.
16. As they rotate, the pulverisers break up the coal into fragments.
17. As soon as the steam passes into the discharge pipe, it condenses.
18. After the liquid is heated for 10 minutes, it should be allowed to cool.
19. While it was entering the harbour, the vessel collided with the sea-wall.
20. Before it is passed back to the boiler, the condensate should be re-heated.

2. Contracted Time Statements (2)

These contracted forms *on, before, while,* etc. + *-ing* are normally used when the subject of both statements is the same, as you have just seen. They are not normally used when the subjects are different. But one other type of statement can be expressed in the same way.

On removing the impurities, the water can be passed back to the boiler.
When installing a boiler, the floor space which is available is very important.

You will notice that this really means:

When we remove thei mpurities ......
and *When we are installing a boiler* ......

EXERCISE

Use the contracted structure to re-write the following statements:

1. Before we apply heat for a weld, the plates should be clamped together.
2. When we use superheated steam, compounding becomes less effective.
3. When we are drilling deep holes, the feed movement should be released from time to time.
4. While we are making an efficiency test on an engine, certain precautions should be observed.
5. When screws are being cut, the lead-screw on the lathe is engaged.
6. When railway tracks are being laid, allowance must be made for expansion.

7. In the construction of locomotives, the provision of a large heating surface is very important.
8. After the roughing cut is taken, the cutting tool should be sharpened.
9. Before the final cut is taken, the exact size of the bar should be measured.
10. Before the dam can be built, the course of the river will have to be diverted.
11. After you have read the book, a summary should be made of the important chapters.
12. Before starting production, extensive tests must be made.
13. In the course of construction of the motorway, vast quantities of earth have to be moved.
14. While the engine was being examined, a number of defects were found.
15. After £1,000,000 were spent on research and development, the whole project was suddenly abandoned.

3. Sequence

When steam enters the turbine, it has a very high *initial* velocity.
When it leaves the turbine, it has a much lower *final* velocity.
As it passes through the turbine, its velocity is *progressively* reduced.

The rows of blades in the turbine are made *progressively* larger.
Each row is a little larger than the *previous* or *preceding* row.
From January to August, the weather gets *progressively* warmer.
Each month is slightly warmer than the *previous* or *preceding* one.

The first steam engine was built during the nineteenth century.
During the *following* or *succeeding* hundred years, it became the main source of power.
The *initial* attempt to solve the problem ended in failure. So did the three *succeeding* attempts. The *final* attempt succeeded.

Subsequent or *later* attempts to repeat the experiment failed.
The condensate is stored in a cooling tower, for *subsequent* use in the condenser.

In a turbine, the steam passes through a *series* or *succession* of wheels holding blades. It passes through them one after the other. Each *successive* row reduces the kinetic energy of the steam. The energy of the steam is *progressively* reduced as it passes through the *successive* rows.

Not every row of blades rotates. There is a rotating ring, *followed by* a stationary ring, and this is *succeeded by* another rotating ring.
Every second ring is a rotating ring.
Every other ring is a rotating ring.
Each alternate ring rotates.
The rotating rings *alternate with* the stationary rings.
Each *alternate* stroke on a two-stroke engine is a working stroke.
Only *one* stroke *in four* of a four-stroke engine is a working stroke.
The strokes occur in a *sequence*.

EXERCISE

Complete these statements:

1. During the past century, there has been a ...... increase in the size of boilers.
2. The metal which was ...... heated is now quenched in a cold liquid.
3. A complicated ...... of operations is necessary to produce steel.
4. As the metal cools, its surface grows ...... harder and tougher.
5. The pneumatic riveter closes the rivet by a quick ...... of blows.
6. The ...... cost of the machines is high, but maintenance and operating costs are low.
7. Modern boilers are designed for higher pressures than those of the ...... century.
8. The exhaust steam is condensed, and can ...... be used again in the boiler.
9. The original design was not very satisfactory, and a ...... of modifications were made over several years.
10. The ...... pressure of the steam before expansion is 60 lb/in^2.
11. The neutrons lose their energy gradually by ...... collisions with other particles.
12. As work went on, the dam grew ...... higher.
13. The manager retired and was ...... by his assistant.
14. After a ...... of tests, the model was put into production.
15. He works ...... shifts: this week he is on the day-shift, and next week he will be on the night-shift.

Section 18

Introduction to Electric Power Systems

CHARACTERISTICS INFLUENCING GENERATION AND TRANSMISSION OF ELECTRICITY

18–01 There are three main characteristics of electricity supply which, however obvious, have a profound effect on the manner in which it is engineered. They are as follows:

a) Electricity, unlike gas and water, cannot be stored and the supplier has small control over the load at any time. Control engineers endeavour to keep the output from the generators equal to the connected load at the specified voltage and frequency. The load consists basically of a steady component known as the base load plus peaks depending on the time of day.

b) There is a continuous increase in the demand for power. A large and continuous process of adding to the system thus exists. Networks are evolved over the years rather than planned in a clear-cut manner and then left untouched.

c) The distribution and nature of the fuel available. This aspect is of great interest and importance.

TEXT COMPREHENSION WITH DISCUSSION

– The author discusses the three main characteristics of electricity supply which have a profound effect on the generation and transmission of electricity. The first characteristic of electricity is that it cannot be stored. Does this statement hold good for gas and water too?

– What is the task of control engineers?

– What does the load basically consist of?

– What do you understand by the term "peak"?

– The second characteristic of electric power systems is that there is a continuous increase in the demand for power. How is this problem solved?

– What is the third characteristic that has to be taken into consideration when dealing with the problem of electricity supply?

RHETORICS

This introductory paragraph is typical of technical English. The author introduces the topic by enunciating the three basic characteristics affecting the generation and transmission of electricity.

The rhetorical device of enumeration gives a clear survey of the problems involved. Do you consider that the order of the given characteristics can be changed in terms of their importance. Are these characteristics functionally interdependent or not?

18–02 **Representa**
invariably three
operation is re
study of the ele
analysis. Equal
as far as possi
distribution fee

18–03 A very use
schematic of lin
lines.

TEXT COMPR

Feeder

– What kinc
– The autho
sufficient to give
– How is eq
– How can a
way?

RHETORICS:

Technical in
of information)
author conduct t
represented as a
Use the foll

18–04 A typical l
figure 17. In th
earth through
rotating machi
considering fau
generator feed
voltage is incr
connected as s

18–02 **Representation of Power Systems.** Modern electricity supply systems are invariably three-phase. The design of distribution networks is such that normal operation is reasonably close to balanced three-phase working, and often a study of the electrical conditions in one phase is sufficient to give a complete analysis. Equal loading on all three phases of a network is ensured by allotting as far as possible equal domestic loads to each phase of the low voltage distribution feeders; industrial loads usually take three-phase supplies.

18–03 A very useful and simple way of graphically representing a network is the schematic ~~of~~ line diagram in which three-phase circuits are represented by single lines. or

TEXT COMPREHENSION WITH DISCUSSION

– What kind of electricity supply systems are used today?

– The author states that often a study of electrical conditions in one phase is sufficient to give a complete analysis. Give arguments for this statement.

– How is equal loading on all three phases ensured?

– How can a three-phase network be graphically represented in a useful and simple way?

RHETORICS: STRUCTURING OF A TEXT

Technical information may be expressed either by words, by a text (the verbal form of information) or be represented by diagrams (the non-verbal form). How does the author conduct the information about the network of the power system which is usually represented as a schematic diagram?

Use the following bearers of information:

design of distribution networks
↓
normal operation
↓
balanced three-phase working
↓
the study of electrical conditions
↓
the analysis of one phase
↓
graphical representation
↓
single line diagram

18–04 A typical line or schematic diagram of a part of a power system is shown in figure 17. In this, the generator is star connected, with star point connected to earth through resistance. The nature of the connection of the star point of rotating machines and transformers to earth is of vital importance when considering faults which produce electrical unbalance in the three phases. The generator feeds two three-phase lines (overhead or underground). The line voltage is increased from that at the generator terminals by transformers connected as shown. At the end of the lines the voltage is reduced for the secondary distribution of power. Two lines are provided to improve the security of the supply, i.e. if one line develops a fault and has to be switched out the remaining one still delivers power to the receiving end. It is not necessary in straight-forward current and voltage calculations to indicate the presence of switches, etc., on the diagram, but in some cases such as stability calculations the location of switches, current transformers and protection is very useful.

(from Electric Power Systems by B. M. Weedy and John Wiley and Sons, 1974)

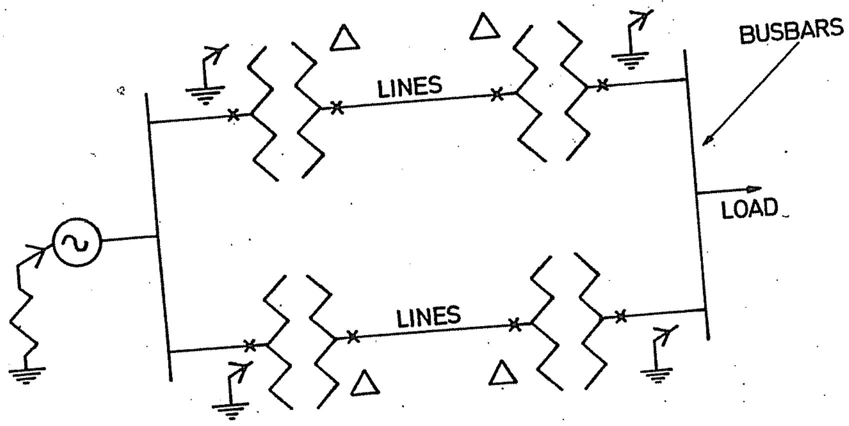


Fig. 17 *Line diagram of a simple system*

Names of the components of a three-phase power system:

- line, cable,
- busbar,
- synchronous machine,
- two winding transformer,
- circuit breaker,
- delta connected,
- current transformer,
- isolator,
- three-phase wire or star connected with the star point solidly connected to an earth or ground electrode.

DISCUSSION ON THE SCHEMATIC DIAGRAM

busbar =

- Explain the symbols.
- Explain how the generator is connected.
- Why is the connection of the star point of rotating machines and transformers to earth of vital importance?
- What does the generator feed?
- What kind of lines may be used?
- Where and how is the line voltage increased?
- Where is the voltage reduced and for what purpose?
- Why are two lines provided?

18–05 **Abstract**

Variant 1

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Variant 2

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19–04 A complete electric circuit consists of a device or appliance, a path, a method of control, and a source of electrical energy. There are numerous electrical devices, appliances, and gadgets for household purposes.

Match the technical term given on the left with its function.

Technical term	*Function*
television	for producing sound and pictures
switch	for safeguarding the circuit
fuse	for producing sound
radio	for producing light
bell	for controlling the current
telephone	for sweeping the dust
refrigerator	for communicating over a certain distance
electric stove	for producing heat
washing machine	for cooling food and drinks
vacuum cleaner	for washing the laundry
electric ring	
toaster	
circuit breaker	
electric iron	

19–05 TECHNICAL TERMINOLOGY

	DEFINITION
rating	A designation, as established by definite standards, of an operating limit of a machine. It may be expressed in kilowatts, e.g. of a d-c generator, in kilovolt amperes, e.g. of an alternator.
	EXAMPLES OF USEFUL EXPRESSIONS
19–06 the fuse blows the circuit breaker trips	The fuse blows whenever an overload occurs. The circuit breaker trips whenever an overload occurs.
19–07 switch on switch off	Switch on the light. Switch it on. Switch off the light. Switch it off.
turn on turn off	Turn on the radio. Turn it on. Turn the radio off. Turn it off.
plug in	Plug in the lamp. Plug in the tape recorder. Plug in the refrigerator.
take out the plug, unplug	Unplug the lamp plug. Take out the recorder plug. Unplug the refrigerator plug.
19–08 connect	The source of emf is connected. All devices are connected in the circuit.
disconnect	When the source of emf is disconnected the current stops flowing.
interrupt	The flow of current is interrupted when the circuit is broken.

19–09 **Abstract**

SWITCHES, CIRCU

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Section 20

Conduction and Transmission of Electric Current

20–01 **Bus Structure.** The bus structure is composed of heavy copper conductors supported on insulators and installed in concrete cells. All generated power is concentrated at the buses. From them it is fed through branch lines (feeders) to points of use. Practice differs widely as to the number and arrangement of the buses, but the principle is that of pooling the output of several generators. Each generator is provided with several switches, by which it can be connected to any bus desired. Instrument transformers, permanently connected to generator circuits, furnish current to actuate the ammeters, voltmeters, wattmeters and watt-hour meters on panel boards in the control room which is the operating headquarters of the electric power plant.

TEXT COMPREHENSION WITH DISCUSSION

– What is the function of the buses?
– What is the bus structure composed of?
– Each generator may be connected to any bus desired. By what?
– Through what is electric current fed from the buses to the points of use?
– Instrument transformers are permanently connected to generator circuits. Give reason for this statement.
– What kind of meters may be found on panel boards in the control room?

20–02 **Switching and Transformer Equipment.** If an electric power plant is serving a near-by load, the feeders will pass directly from the bus structure to the pole lines or underground cables. Groups of switches are used to connect the feeder to one bus or another for most economical operation according to the amount of load. If the plant output is to be transmitted to distant load centres, the voltage is stepped up by transformers in order that the resultant reduced currents will cause a reduced amount of heating in the lines. As the voltage is increased the current is decreased in inverse proportion. This permits the use of smaller conductors and affords a saving in construction and operating costs. Part of the saving in conductor costs is offset by the fact that operation at higher voltages requires increased clearance between the wires and towers and the ground, increased spacing between wires and increased cost of insulators. Voltages are stepped up by large power transformers, connected between generators and buses or between buses and feeders. Switching between transformers and transmission lines is usually done by high-voltage oil circuit breakers. Switching and transforming equipment is often installed outdoors and is designed for severe weather conditions. Plants in congested districts usually have indoor switch houses feeding into underground cables.

TEXT COMPREHEN

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20–03 **Transmission Line**
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20–05 ELECTRIC CU

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TEXT COMPREHENSION WITH DISCUSSION

– The author mentions two systems of electric supply service: one when the electric power plant is serving a near-by load, and the other when it is serving distant load centres. Describe these systems.

– If the power plant output is to be transmitted to distant load centres the voltage is stepped up by transformers. Give technical reason for this statement.

– As the voltage is increased the current is decreased in inverse proportion. This affords different kinds of savings. What savings?

– Voltages are stepped up by large power transformers. Where are they located and how are they connected?

– What devices perform the switching between transformers and transmission lines?

– Where are switching and transforming equipment usually installed?

20–03 **Transmission Lines.** Transmission lines may be underground or overhead. For long distances overhead lines are used exclusively. For shorter distances, in residential and industrial communities, underground cables are often used. When lines are overhead, the conductors are supported from the poles or towers by insulators mounted on crossarms.

20–04 Transmission conductors are usually made of several strands of metal twisted together in spirally wound layers. Copper conductors of the necessary diameters would often contain more metal than could be justified economically. Conductors of aluminium wound around a core of steel strands have a larger diameter for the same resistance, and after World War II, had a lower cost. As the result, the use of aluminium increased greatly.

TEXT COMPREHENSION WITH DISCUSSION

– There are two systems of transmitting current. What are they?

– What is the name of the structure on which the transmission lines are strung?

– On what are the insulators mounted that support the transmission conductors?

– What does the transmission conductor consist of?

– What factors affect the choice of a conductor?

(from Encyclopaedia Britannica, vol. 8)

20–05 ELECTRIC CURRENT-FLOW DIAGRAM

The diagram shows the main points where electric current is generated, transformed and fed to the transmission lines. The detailed description of the diagram starts from the left top side and follows the arrows to the transmission lines at the bottom.

The sentences that follow denote individual stages of the current flow. If you link these sentences together and reconstruct them if necessary, and if you add the necessary connective words, you will obtain a cohesive whole, i.e. a complete descriptive text of the current-flow diagram.

Since this description follows the current flow in a logical order, the text of this description is said to be coherent. In other words, from the beginning to the end of the description the sentences are logically developed one from the other, thus making a logical whole.

– The heat energy of steam is converted to mechanical energy of rotation, which in turn is converted to electrical energy.

– Steam is produced in a steam turbine.

– Electrical energy is produced in a generator.

– The mechanical energy of rotation is delivered on the turbine shaft.

– The turbo-generator set is mounted on the same shaft.

– The synchronous a-c generator is separately excited by the exciter, a small d-c generator.

– The exciter supplies the main generator with the field current.

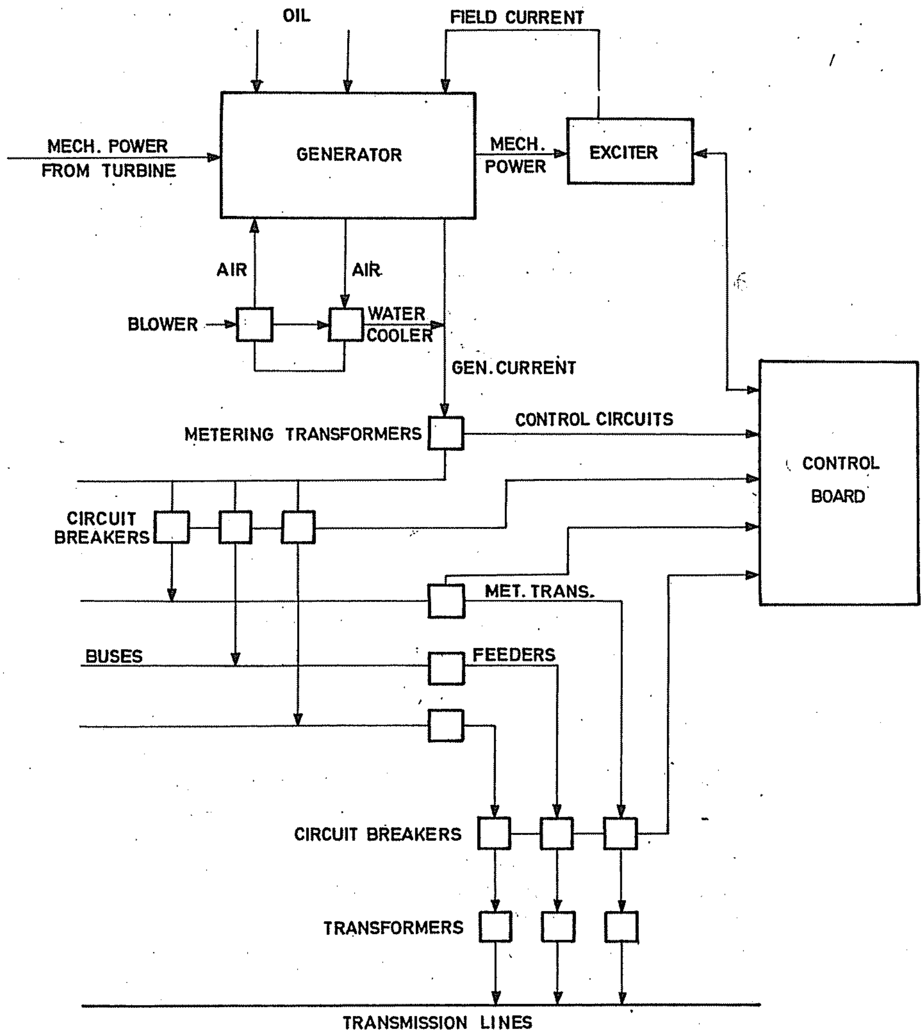

Fig. 18 *Electric Current-Flow Diagram*

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20–06 ELECTRIC POW

Thermal power plar

Hydroelectric powe

Nuclear power plan

20–07 Costs

20–08 **Abstract**

CONDUCTION

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– The turbo-generator set would get very hot if it were not cooled, so some kind of cooling system must be provided.

– The metering transformers transform the generated current to the value required for the control circuits connected to the control board.

– Meters and instruments are mounted on an easily accessible switchboard.

– They indicate and record electrical quantities in all circuits.

– Switches are located on the board for controlling the circuit breakers.

– The operators in charge are informed about every piece of apparatus included in the system.

– All power generated from the output of several generators is concentrated at the buses.

– The generated power is fed through the feeders to the transformers.

– Transformers step up the voltage to high value.

– As the voltage is increased the current is decreased in inverse proportion.

20–06 ELECTRIC POWER PLANTS – ENERGY CONVERSION

Thermal power plant:	The chemical energy of burning fuel is changed to the heat energy of steam, which in turn is changed to mechanical and then to electrical energy.
Hydroelectric power plant:	The kinetic energy of flowing water is changed to mechanical energy and then to electrical energy.
Nuclear power plant:	The nuclear energy in the reactor is changed to heat energy, then to mechanical energy and finally to electrical energy.

20–07 Costs

investment costs,
maintenance or upkeep costs,
operating costs or costs of operation,
repair costs,
replacement costs

20–08 **Abstract**

CONDUCTION AND TRANSMISSION OF ELECTRIC CURRENT

The author describes the conduction and transmission of electric current with devices and equipment required for this purpose. The current is produced in turbo-generator sets. The power generated from their output is concentrated at the buses from which it is fed through feeders to power transformers. If the output is to be transmitted to distant load centries, the voltage must be stepped up by transformers, because if the voltage is increased the current is decreased in inverse proportion. This permits the use of smaller conductors and affords a saving in construction and operating costs. Further on, the author discusses the transmission lines that may be overhead or underground. Overhead transmission lines are predominantly made today of aluminium conductors wound around a steel core because aluminium is cheaper than copper. Underground cables are used for local distribution of current in residential and industrial districts.

Circuit breaker

A **circuit breaker** is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by excess current from an overload or short circuit. Its basic function is to interrupt current flow after a fault is detected. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation.

Circuit breakers are made in varying sizes, from small devices that protect low-current circuits or individual household appliance, up to large switchgear designed to protect high voltage circuits feeding an entire city. The generic function of a circuit breaker, RCD or a fuse, as an automatic means of removing power from a faulty system is often abbreviated as OCPD (Over Current Protection Device).

All circuit breaker systems have common features in their operation, but details vary substantially depending on the voltage class, current rating and type of the circuit breaker.

The circuit breaker must first detect a fault condition. In small mains and low voltage circuit breakers, this is usually done within the device itself. Typically, the heating or magnetic effects of electric current are employed. Circuit breakers for large currents or high voltages are usually arranged with protective relay pilot devices to sense a fault condition and to operate the opening mechanism.

Once a fault is detected, the circuit breaker contacts must open to interrupt the circuit; this is commonly done using mechanically stored energy contained within the breaker, such as a spring or compressed air to separate the contacts. Circuit breakers may also use the higher current caused by the fault to separate the contacts, such as thermal expansion or a magnetic field. Small circuit breakers typically have a manual control lever to switch off the load or reset a tripped breaker, while larger units use solenoids to trip the mechanism, and electric motors to restore energy to the springs.

The circuit breaker contacts must carry the load current without excessive heating, and must also withstand the heat of the arc produced when interrupting (opening) the circuit. Contacts are made of copper or copper alloys, silver alloys and other highly conductive materials. Service life of the contacts is limited by the erosion of contact material due to arcing while interrupting the current. Miniature and molded-case circuit breakers are usually discarded when the contacts have worn, but power circuit breakers and high-voltage circuit breakers have replaceable contacts.

When a high current or voltage is interrupted, an arc is generated. The length of the arc is generally proportional to the voltage while the intensity (or heat) is proportional to the current. This arc must be contained, cooled and extinguished in a controlled way, so that the gap between the contacts can again withstand the voltage in the circuit

Section 21

Transformers

21–01 A transformer consists of two windings and an iron core, the first coil may be said to be the primary, and the coil in which the phenomena are observed may be called the secondary. Together with their mutual relations, they constitute the essentials of the transformer. The coils are placed in close proximity to each other and the current in either is changed from one value to another.

TEXT COMPREHENSION WITH DISCUSSION

– What are the essential parts of the transformer regardless of the type?
– What is the function of a transformer?
– Why are the coils in a transformer in close proximity?

21–02 If two circuits are in close proximity to each other, the current in either one will produce flux which links both circuits. These flux linkages are mutual linkages and the circuits are said to be coupled by way of the flux. Figure 19. An alternating current in one circuit will induce voltage in the second circuit because of the accompanying change in flux linkages, the voltage being the voltage of mutual induction. Such phenomenon is voltage generation by transformer action.

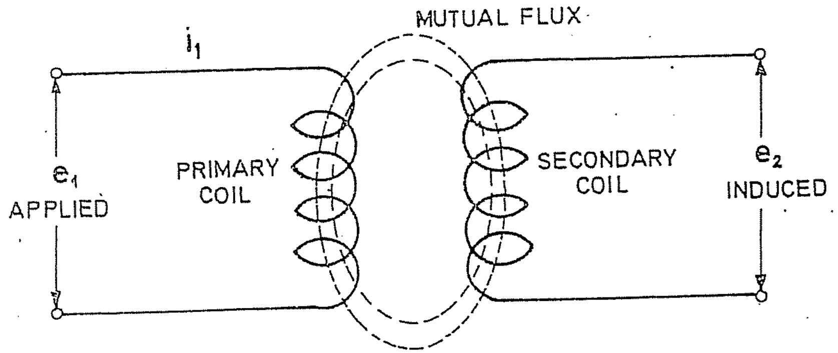

Fig. 19 *Mutual flux in a coupled circuit*

Explain the phenomenon that is illustrated in Figure 19. Is this phenomenon only used in transformers?

21–03 ELECTRICAL CHARACTERISTICS

Transformer Impedance. The turns ratio of a two-winding transformer determines the ratio between primary and secondary terminal voltages, when the transformer load current is zero. However, when load is applied to the transformer, the load current encounters an apparent impedance within the transformer which causes the ratio of terminal voltages to depart from the actual turns ratio. This internal impedance consists of two components: 1) a reactance derived from the effect of leakage flux in the windings, and 2) an equivalent resistance which represents all losses traceable to the flow of load current, such as conductor I^2 R loss and stray eddy-current loss. Impedance drop is conveniently expressed in percent, and is the impedance-drop voltage expressed as a percentage of rated terminal voltage, when both voltages are referred to the same circuit.

TEXT COMPREHENSION WITH DISCUSSION

– What does the turn ratio of a two-winding transformer determine?
– What does the load current encounter when load is applied to a two-winding transformer?
– The author discusses the term "apparent impedance within the transformer".
– What kind of effect has this kind of impedance?
– Internal impedance within the transformer consists of two components. What are they?

21–04 **Forms of Construction.** Core-form construction for single-phase transformers consists of magnetic steel punchings arranged to provide a single-path magnetic circuit. High-and low-voltage coils are grouped together on each main or vertical leg of the core. In general, the mean length of turn for the winding is comparatively short in the core-form design, while the magnetic path is long.
21–05 Shell-form construction for single-phase transformers consists of all windings formed into a single ring, with magnetic punches assembled so as to encircle each side of the winding ring. The mean length of turn is usually longer than for a comparable core-form design, while the iron path is shorter.

TEXT COMPREHENSION WITH DISCUSSION

– Describe the core-form construction for single-phase transformers.
– What is the characteristic mean length of turn for the winding and that for the magnetic path in a core-type of transformer?
– Describe the shell-form construction for single-phase transformers.
– What is the characteristic mean length of turn for the winding and that for the iron path in a shell-type of transformer?

21–06 **Factors in the Design.** In the design of a particular transformer many factors such as insulation stress, mechanical stress, heat distribution, weight and cost must be balanced and compromised. It appears that, for a well-balanced design, both core-form and shell-form units have their respective fields of applicability determined by kVA and KV rating.

28 Dec 2012 | 16:09 GMT

Japan's Digital Grid Scheme

Japanese consortium aims to transform the country's centralized grid into islands of interconnected cells

By John Boyd

Japan's plan to phase out its nearly 50 gigawatts of nuclear capacity over the next two to three decades has opened a window for renewable energy in the country. But swapping wind and solar power for that nuclear generation, which produced 30 percent of Japan's electricity prior to the 2011 Fukushima crisis, could also lead to major disruptions in energy supply, warns Rikiya Abe, a University of Tokyo professor. The problem, says Abe, who came to academia after working in the electrical generation industry for 30 years, is that Japan's grid—and indeed that of many developed countries—is set up to be centrally controlled. The utilities have to carefully regulate the grid's frequency and voltage by maintaining a fine balance between power generation and changing demand. A diverse group of large Japanese firms is starting to explore a solution—a gradual reorganization of the country's power system so that in the end it resembles the Internet, routers and all.

"The present synchronized system has served us well," says Abe. "But when you introduce various sources of renewable energy, they will certainly increase fluctuations in the system, until at some point they become unmanageable." What we need, he says, "is a shift from central to decentralized control, with generated power being segmented and widely distributed."

The answer is what he calls "the digital grid," the architecture of which is based on the Internet. The idea is to gradually subdivide the existing synchronized grid into asynchronous, autonomous but interconnected cells of varying sizes. These assign the equivalent of IP addresses to generators, power converters, wind farms, storage systems, rooftop solar cells, and any other grid infrastructure within the cells.

"Theoretically it's sound; technically it's doable," says Paul Scalise, a former energy analyst who is now a research fellow at Temple University Japan and the University of Tokyo. "And it has the added benefit of dealing with the renewable energy issue," he says. "So it's an idea that could hold sway with utility companies worldwide. The question is, though, who is going to pay for it?"

To get the concept off the ground, last September Abe established the Digital Grid Consortium, which he heads. To date it has six members: Hitachi Yokohama Research Laboratory, Kanematsu Electronics, National Instruments Japan, NEC, Orix Corp., and Sekisui Chemical. In the same month, Abe says, the group successfully demonstrated a key enabling technology—the Mark I, a 2-kilowatt, three-legged "digital grid router." DGRs would manage and regulate power demands by providing asynchronous connections and coordination within and between cells. The multilegged DGR comprises a solid-state AC/DC/AC converter using insulated gate bipolar transistors and other power electronics. These enable voltages to be raised or lowered on the fly as cell frequencies change, according to various demands. Early next year, the consortium plans to demonstrate two or more routers working together at the Knoxville, Tenn., Electric Power Research Institute test facility.

Equipped with a CPU, memory, data storage, and network communications, a DGR assigns tags (the equivalent of IP addresses) to discrete "packets" of power from various generated or stored sources that are sent into the grid, while receivers simultaneously extract the same amount of power from the grid. To illustrate how this would work, Abe gives as an example a cooperative residential group that puts in an order for renewably generated power at a certain cost. Using an Internet-based market mechanism similar to a stock exchange system for buying and selling securities, a broker locates a solar farm that accepts the order, and a contract is agreed on. "If the order is not matched, then there is no transaction," he says. "This maintains balance in the grid."

Abe likens the process to the banking system. If one person remits money to another person, the cash need not be physically transported to complete the transaction. The actual communication in the digital grid is done primarily over the Internet, or in the case of power lines, by adding on a high frequency signal. "Each energy transaction will automatically be recorded and collected by certified service providers, along with additional properties such as location, time, generation source, price, and CO_2 credits," he says.

Since the 2011 earthquake, Abe says he's seen a great upsurge of interest in the concept, but he agrees that to turn the digital grid into a viable reality in Japan, he will have to win over the power utilities and major electrical equipment manufacturers, which so far have declined to join the consortium, "though we continue to talk with them and with METI [Ministry of Economy, Trade and Industry]," he says. "Eventually, they will have to accept the reality of renewably generated energy and [that] the present system is not set up to manage it," says Abe. "If they're going to remain key players in the coming renewable energy era, they really need to start changing their present business model."

Scalise, author of an upcoming book on Japan's energy restructuring effort, agrees. "Any developed country moving towards a renewable energy portfolio will sooner or later have to deal with the transmission and distribution grid issue," he says. "And this is going to apply as much to the United States as it does to Europe."

In the meantime, the consortium is continuing to improve the DGR and has begun looking for opportunities to introduce the technology first in an underdeveloped country where countrywide grids don't exist. "In such countries…they may not even require a conventional grid system over the long run," Abe says.

This article originally appeared in print as "An Internet-Inspired Electricity Grid."

17 Mar 2018 | 13:00 GMT

Origami-Folded Hydrogel Paper Instantly Generates 110 Volts of Electricity

Researchers combine 3D-printed hydrogels and origami to create an electric eel-inspired power source

By Christina Dabney

Animal-inspired technology has gone electric. These brightly colored, 3D-printed gels have the potential to create up to 110 volts of electricity in an instant, similar to the electric eel.

Rows of small hydrogel dots are packed with positively and negatively charged ions that combine together to mimic an electric eel's cellular structure. Printing and stacking these hydrogels produces the highest amount of voltage, while a connection to a larger contact area produces the highest current. Scientists are hoping that this system could potentially lead to a device that generates power from inside of the human body.

"The electric eel is able to create very, very large amounts of power. And we thought that this was remarkable," said Anirvan Guha, one of the researchers on the project, designed at the University of Fribourg in Switzerland. "So we started to think about whether or not we could create a system that could generate electricity in the same way."

An eel's unique ability comes from a specialized organ housing thousands of cells called electrocytes. The chemical make up of these cells allows for a positive or negative charge. The surrounding membranes control the charge by allowing ions to pass through, inciting an electric reaction, or by blocking the ions and returning the organ to a neutral, dormant state.

When an eel is threatened or stalking prey, a neural impulse is sent to the membranes in the electrocytes, and positive ions flood into the cells. In a second, the electric voltage in each cell can go from zero millivolts to 150 millivolts, producing a total of up to 600 volts.

This new power generator works in a similar way.

It uses four different types of hydrogels to mimic the eel's electrical system. One with a high salt concentration, one with a low salt concentration, and two charged membranes—one negative and one positive.

The first attempt at putting this system together involved using a fluidic autosampler that pushed the gels into sequence in tubes. The more gels in a sequence, the higher the voltage. But the researchers couldn't build an array long enough to produce the desired voltage.

So the researchers moved on to 3D printing. They printed a sequence of about 2,500 gels on two plastic sheets the size of regular printer paper. When they connected two gel papers, they were able to produce 110 volts of charge within seconds.

This was a huge jump in electricity from the previous method, but the current was still too low for most practical applications.

At the suggestion of a colleague, they tried connecting the gels through a Miura-ori fold, a type of origami fold that allows the gels to stack on a folded sheet. The gels connect simultaneously with a large contact area, more closely resembling the geometry of the eel's cells. This method increased the current and prevented energy waste by decreasing the time it took for the gels to connect.

Guha says he and his team would love to find a way to make the hydrogels thinner, which would allow for an even higher current. They imagine that one day this system, or one like it, could be used to power internal biological devices such as pacemakers.

"Because the power source is ionic gradients," Guha says, "our hope is that you could implant one of these devices and the power could be maintained from the ionic gradients within the human body."

https://spectrum.ieee.org/video/biomedical/devices/origamifolded-hydrogel-paper-instantly-generates-110-volts-of-electricity