Министерство науки и высшего образования Российской Федерации
Федеральное государственное бюджетное образовательное учреждение
высшего образования
«Амурский государственный университет»

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ENGLISH FOR POWER ENGINEERING STUDENTS

УЧЕБНОЕ ПОСОБИЕ ПО АНГЛИЙСКОМУ ЯЗЫКУ ДЛЯ СТУДЕНТОВ ЭНЕРГЕТИЧЕСКИХ СПЕЦИАЛЬНОСТЕЙ

по направлению подготовки 13.03.02 «Электроэнергетика и электротехника» профиль «Электроэнергетика»;

по направлению 15.03.04 «Автоматизация технологических процессов и производств» профиль «Автоматизация технологических процессов и производств в энергетике»

Благовещенск
Издательство АмГУ
2022

ББК 81.2Англ я73
С 50

Печатается по решению
редакционно-издательского совета
филологического факультета
Амурского государственного
университета

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Смирнова О. Г., Процукович Е. А. **English for Power Engineering Students.** Учебное пособие по английскому языку. 2-е изд., перераб. и доп. / О. Г. Смирнова, Е. А. Процукович. – Благовещенск: Амурский гос. ун-т, 2022. – 195 с.

Учебное пособие составлено в соответствии с программой курса «Иностранный язык» и «Профессиональный иностранный язык». Пособие содержит тексты научно-технического характера по энергетике и комплекс заданий с учетом профессиональных интересов обучаемых и соблюдением принципа междисциплинарности обучения.

Предназначено для развития профессионально-коммуникативных умений и навыков у студентов энергетических специальностей. Рекомендуется как для аудиторной, так и для самостоятельной подготовки студентов 2-3 курсов к профессионально-ориентированному иноязычному общению. Может быть полезно аспирантам и преподавателям иностранного языка в сфере иноязычной профессиональной коммуникации.

В авторской редакции

ББК 81.2 Англ я 73

ПРЕДИСЛОВИЕ

Дисциплина «Иностранный язык» относится к дисциплинам обязательной части блока Б 1 ОП. Данная дисциплина концептуально связана с такими дисциплинами других циклов как «Общая энергетика», «Электроэнергетические системы и сети», «Электроснабжение» и другими.

Дисциплина «Профессиональный иностранный язык» относится к дисциплинам вариативной части образовательной программы. Дисциплина, с одной стороны, предполагает успешное овладение дисциплиной «Иностранный язык», а с другой – связана со следующими дисциплинами профессионального цикла: «Общая энергетика», «Электроэнергетические системы и сети», «Безопасность жизнедеятельности».

Дисциплина «Иностранный язык» предполагают формирование и развитие у студентов универсальной компетенции УК-4 «Способность осуществлять деловую коммуникацию в устной и письменной формах на государственном языке Российской Федерации и иностранном(ых) языке(ах)». Индикатором данной компетенции является умение выпускника вести обмен деловой информацией в устной и письменной формах не менее чем на одном иностранном языке.

В процессе освоения дисциплины «Профессиональный иностранный язык» студент формирует и демонстрирует следующие общекультурные компетенции (ОК) и профессиональные компетенции (ПК):

- способность к коммуникации в устной и письменной формах на русском и иностранном языках для решения задач межличностного и межкультурного взаимодействия (ОК-3).

- способность аккумулировать научно-техническую информацию, отечественный и зарубежный опыт в области автоматизации технологических процессов и производств, автоматизированного управления жизненным циклом продукции, компьютерных систем управления ее качеством (ПК-18).

Целью настоящего учебного пособия является взаимосвязанное развитие у студентов коммуникативной компетенции, достаточной для осуществления общения в соответствии с программой обучения, а также обеспечение развития умений и навыков эффективной работы с текстами профессиональной направленности на английском языке.

При разработке системы заданий положен принцип интегративности обучения иностранному языку, предполагающий комплексную тематическую организацию учебного материала для взаимосвязанного обучения всем видам речевой деятельности.

В учебном пособии уделяется внимание работе по усвоению лексических единиц общей и, особенно, профессиональной направленности. Выполнение ряда упражнений предполагает развитие навыков говорения на профессиональные темы, что, безусловно, поможет проводить обоснование тех или иных предлагаемых проектных решений в области энергетики и электротехники на английском языке.

В качестве материала для данных методических указаний были использованы статьи с официальных сайтов свободного доступа Renewable-Energy-Technology Net, Engineering News, Energy Policy, International Journal of Electrical Power & Energy Systems, IEEE Transactions on Power Systems.

СТРУКТУРА УЧЕБНОГО ПОСОБИЯ

Каждый из восьми тематических разделов (Units) содержит необходимый лексический минимум по теме, аутентичные тексты профессиональной направленности, упражнения, часть которых выполняется во время чтения, а часть – на послетекстовом этапе. Выбор тем коммуникации обуславливается возможностью формирования навыков и умений, лежащих в основе развития навыков профессионально-ориентированного иноязычного общения.

В текстах рассматривается спектр тем, соответствующих профессиональным интересам студентов направлений подготовки 13.03.02 «Электроэнергетика и электротехника», 15.03.04 «Автоматизация технологических процессов и производств».

В рамках курса студентам предлагаются к освоению следующие темы коммуникации:

- *«Электричество»;*
- *«История электричества»;*
- *«Электрический ток»;*
- *«Виды тока»;*
- *«Источники питания»;*
- *«Измерительные приборы»;*
- *«Проводники», «Полупроводники», «Диэлектрики»;*
- *«Генераторы»;*
- *«Трансформаторы»;*
- *«Электрические двигатели» и др.*

Послетекстовые упражнения представлены упражнениями на поиск эквивалентов (English Equivalents), на словообразование (Word Building), на определение синонимов (Rephrase) и заполнение пропусков (Fill in the Gaps), составление диалогов (Dramatize the Dialogues). Детальное понимание текста проверяется с помощью вопросов (Questions) и верных / неверных утверждений (True or False).

Пособие также содержит дополнительные тексты по темам соответствующим профессиональным интересам студентов (Supplementary Texts), статьи для аннотирования и реферирования (Texts for Rendering), примерный план для составления аннотации и реферата статьи (Supplements), англо-русский словарь по энергетике (English-Russian Dictionary) и список сокращений (Appendix).

UNIT I

ELECTRICITY

I. Study the words given below; make up sentences with these words.

property	свойство
network	сеть
consumption	потребление
indicator	показатель
improved	улучшенный
reduced	уменьшенный
advantage	преимущество
beam	луч
transmission shaft	трансмиссионный вал
gearwheel	зубчатое колесо
belt	ремень
pulley	блок, барабан
labor saving appliance	электроприбор, экономящий труд
induction motor	асинхронный двигатель
per capita	на человека
by-product	побочный продукт
truly	поистине

II. Translate the text and enumerate the most important inventions in the field of electrical engineering.

ELECTRICITY

It is impossible to imagine our civilization without electricity: economic and social progress will be turned to the past and our daily lives completely transformed.

Electrical power has become universal. Thousands of applications of electricity such as lighting, electrochemistry and electrometallurgy are longstanding and unquestionable.

With the appearance of the electrical motor, power cables replaced transmission such things as shafts, gear wheels, belts and pulleys in the 19-th century workshops. And in the home a whole range of various time and labor saving appliances have become a part of our everyday lives.

Other devices are based on specific properties of electricity: electrostatics in the case of photocopying machine and electromagnetism in the case of radar and television. These applications have made electricity most widely used.

The first industrial application was in the silver workshops in Paris. The generator – a new compact source of electricity – was also developed there. The generator replaced the batteries and other devices that had been used before.

Electric lighting came into wide use at the end of the last century with the development of the electric lamp by Thomas Edison. Then the transformer was invented, the first electric lines and networks were set up, dynamos and induction motors were designed.

Since the beginning of the 20-th century the successful development of electricity has begun throughout the industrial world. The consumption of electricity has doubled every ten years.

Today consumption of electricity per capita is an indicator of the state of development and economic health of a nation. Electricity has replaced other sources of energy as it has been realized that it offers improved service and reduced cost.

One of the greatest advantages of electricity is that it is clean, easily-regulated and generates no by-products. Applications of electricity now cover all fields of human activity from house washing machines to the latest laser devices. Electricity is the efficient source of some of the most recent technological advances such as the laser and electron beams. Truly electricity provides mankind with the energy of the future.

III. Answer the questions on the text.

1. What industrial applications of electricity do you know?
2. What home applications of electricity do you know?
3. Where was the generator developed?
4. Who invented the electric lamp?
5. Do you know who invented the dynamo?
6. Can you imagine our life without electricity? Why?

IV. Define the function of the verb to have.

1. Electricity has many useful properties: it is clean and generates no by-products.
2. The latest laser devices have found application in medicine.
3. It has many important applications in industry as well as in our houses.
4. No other source of energy has been so widely used as electricity.
5. Electricity has provided mankind with the most efficient source of energy.
6. We have many various electric devices in our houses.
7. Our lives have been completely transformed with the appearance of electricity.
8. The generator replaced batteries that had been used before.
9. The consumption of electricity has doubled every ten years.

V. Make up dialogues on the following topics:

a) important inventions in the field of electrical engineering:

b) areas of application of electricity in the national economy and human life;

c) importance of the invention of electricity.

VI. Translate dialogues, guess the meaning of the words and expressions concerned with the field of electrical engineering.

1.

– Послушай, что ты так волнуешься?

– Да у меня зачёт по электротехнике!

– Насколько я знаю, ты хорошо знаешь этот предмет.

– Я полагаю, что так. Но кто знает.

– Если хочешь, я тебя проэкзаменую.

– Я не против.

– Кто изобрёл гальванометр?

– Ты думаешь, что я назову Алоизио Гальвани? Ошибаешься! Он был открыт Алессандро Вольта. А Гальвани только отметил это явление. И то не он, а его жена.

– Ну вот! Так чего же ты боишься?

– Ты думаешь, что на зачёте все вопросы будут такие?

2.

– Почему ты выбрал профессию инженера-энергетика?

– Потому что электричество – самый чистый источник энергии. Потребление электричества возрастает с каждым годом. Только представь, какое количество электробытовых приборов работает на электричестве.

– Я вполне с тобой согласен. Ещё больше электричества потребляет промышленность. Не могу назвать ни одной отрасли, где бы оно ни применялось.

– Вот видишь! Скоро и улицы наших городов станут гораздо чище, так как автомобили тоже перейдут на электропривод.

– Ты прав, что выбрал эту профессию!

3.

– О, Иван, как я рад тебя видеть! Привет! Как поживаешь?

– Я тоже не видел тебя целую вечность! Как ты?

– Ты знаешь, я ведь учусь в АмГУ. Уже второй курс!

– А какой факультет?

– Энергетический.

– Да ты что! Никогда не думал, что ты выберешь инженерную специальность.

– По-моему, инженерная специальность – это основа науки.

– Возможно, ты прав. Ты так увлечён, что я в какой-то степени тебе завидую!

4.

– Чем ты занимаешься?

– Тише, я провожу эксперимент! Ты знаешь, что полюса, имеющие разные заряды, притягиваются, а одинаковые – отталкиваются?

– Ну и что?

– Наши с Юлей волосы имеют одинаковые заряды. Дело в том, что её волосы отталкиваются от моей расчёски.

– Ну и какие же заряды вы имеете?

– Честно говоря, не знаю.

– А какой прибор может это измерить?

– Я такой индикатор ещё не создал.

5.

– Что ты знаешь об электромагнитной индукции?

– Дай подумать. Насколько я знаю, заряженный проводник является центром магнитного поля. Стёджен обнаружил, что любой кусок железа, помещённый внутрь катушки, по которой проходит ток, становится магнитом.

– Да, так оно и есть. Стёджен построил новый электромагнит. Это его достижение дало толчок к развитию телеграфа и телефона.

– Подводя итог, можно сказать, что у наших предков было хорошее воображение, так как им удалось сделать такие удивительные открытия.

6.

– Имеется ли связь между электричеством и магнетизмом?

– Безусловно. Ещё Стёджену и Фарадею удалось установить, что электричество может вызывать магнетизм. И магнетизм может вызывать электричество.

– Насколько я помню, Фарадей открыл электромагнитную индукцию. Он доказал, что существуют различные пути превращения движения в электрический ток.

– Да, это было открытие века. Человечество до сих пор им пользуется.

UNIT II

HISTORY OF ELECTRICITY

I. Study the following words and word constructions.

to give vent to smth	давать выход чему-либо
to set the ball rolling	начать новую страницу
to credit smb with smth	называть кого-либо кем-либо
to dawn on smb	осенять кого-либо
to win a day	одержать победу
on the spur of the moment	экспромтом
to become all the rage	стать очень модными
voltaic pile	гальваническая батарея
now and then	время от времени
to begin to tackle smth	взяться за решение чего-либо
with the systematic energy	со всей серьёзностью
to slump	упасть в цене
to stake smth	рискнуть чем-либо
to throw a switch	включить рубильник
to come to stay	получить признание
squirrel-cage motor	короткозамкнутый двигатель
a great deal	значительно
to have smb's eyes on smth	обратиться к чему-либо
to be very much "in the air"	давно витать в воздухе
to appeal most	нравиться больше всего
bucket-shaped blade	ковшеобразная лопасть
by overhead cable	по воздушному кабелю
to step down	понижаться
diehard	консерватор

a good deal of justification	большие основания
to catch on	привиться
to gain ground	шагнуть вперёд
by no means	ни в коей мере
to outstay welcome	устаревать
as long ago as	ещё в какое-либо время
to work “cold”	не нагреваться во время работы
would-be	мечтающий сделать что-либо
to raise funds	извлечь выгоду

II. Read and translate the texts below.

III. Study the concept of an abstract (see Supplement). Write the abstract to the texts.

IV. Study the concept of a rendering (see Supplement). Write the rendering to the texts below.

EARLY DAYS OF ELECTRICITY

There is electricity everywhere in the world. It is present in the atom, whose particles are held together by its forces; it reaches us from the most distant parts of the universe in the form of electro-magnetic waves. Yet we have no organs that could recognize it as we see light, hear sound. We have to make it visible, tangible or audible; we have to make it perform work to become aware of its presence. There is only one natural phenomenon which demonstrates it unmistakably to our senses of seeing and hearing – thunder and lightning; but we recognize only the effects – not the force which causes them.

Small wonder, then, that Man lived for ages on this earth without knowing anything about electricity. He tried to explain the phenomenon of the thunderstorm to himself by imagining that some gods or other supernatural creatures were giving vent to their heavenly anger, or were fighting battles in the sky. Thunderstorms frightened our primitive ancestors; they should have been grateful to them instead because lightning gave them their first fires, and thus opened to them the road to civilization. It is a fascinating question how differently life on earth would have developed if we had an organ for electricity.

We cannot blame the ancient Greeks for failing to recognize that the force which causes a thunderstorm is the same which they observed when rubbing a piece of amber: it attracted straw, feathers, and other light materials. Thales of Miletus, the Greek philosopher who lived about 600 BC, was the first who noticed this. The Greek word for amber is “electron”, and therefore Thales called that mysterious force electric. For a long time it was thought to be of the same nature as the magnetic power of the lodestone since the effect of attraction seems similar, and in fact there are many links between electricity and magnetism.

There is just a chance, although a somewhat remote one, that the ancient Jews knew something of the secret of electricity.

Perhaps the Israelites did know something about electricity; this theory is supported by the fact that the Temple at Jerusalem had metal rods on the roof which must have acted as lightning-conductors. In fact, during the thousand years of its existence it was never struck by lightning although thunderstorms abound in Palestine.

There is no other evidence that electricity was put to any use at all in antiquity, except that the Greek women decorated their spinning-wheels with pieces of amber: as the woolen threads rubbed against the amber it first attracted and then repelled them – a pretty little spectacle which relieved the boredom of spinning.

More than two thousand years passed after Thales’s discovery without any research work being done in this field. It was Dr. William Gilbert, Elizabeth the First’s physician-in-ordinary, who set the ball rolling. He experimented with amber and lodestone and found the essential difference between electric and magnetic attraction. For substances which behaved like amber – such as glass, sculpture, and sealing wax – he coined the term “electrica”, and for the phenomenon as such the word “electricity”. In his famous work “De magnete”, published in 1666, he gave an account of his studies. Although some sources credit him with the invention of the first electric machine, this was a later achievement by Otto von Guericke, inventor of the air pump. Von Guericke’s electric machine consisted of large, disc spinning between brushes; this made sparks leap across a gap between two metal balls. It became a favorite toy in polite society but nothing more than that. In 1700, an Englishman by the name of Francis Hawksbee produced the first electric light: he exhausted a glass bulb by means of a vacuum pump and rotated it at high speed while rubbing it with his hand until it emitted faint glow of light.

A major advance was the invention of the first electrical condenser, now called the Leyden jar, by a Dutch scientist, a water-filled glass bottle coated inside and out with metallic surfaces, separated by the non-conducting glass; a metal rod with a knob at the top reached down into the water. When charged by an electric machine it stored enough electricity to give anyone who touched the knob a powerful shock. More and more scientists took up electric research. A Russian scientist Professor Reichmann from St. Petersburg was killed when he worked on the same problem.

Benjamin Franklin, born in Boston, was the fifteenth child of poor soap-boiler from England. He was well over 30 when he looked up the study of natural phenomena. “We had for some time been of opinion, that the electrical fire was not created by friction, but collected, being really an element diffused among, and attracted by other matter, particularly by water and metals”, – wrote Franklin in 1747. Here was at last a plausible theory of the nature of electricity, namely, that it was some kind of “fluid”. It dawned on him, that thunderstorms were merely a discharge of electricity between two objects with different.

He saw that the discharging spark, the lightning, tended to strike high buildings and trees, which gave him an idea of trying to attract the electrical “fluid” deliberately to the earth in a way that the discharge would do no harm.

In order to work this idea out he undertook his famous kite-and-key experiment in the summer of 1755. It was much more dangerous than he realized. During the approach of thunderstorm, he sent up a silken kite with an iron tip; he rubbed the end of the kite string, which he had soaked in water to make it a good conductor of electricity, with a large iron key until sparks sprang from the string – which proved his theory. Had the lightning struck his kite he, and his small son whom he had taken along, might have lost their lives.

On the next experiment he fixed an iron bar to the outer wall of his house, and through it charged a Leyden jar with atmospheric electricity. Soon after this he was appointed Postmaster General of Britain’s American colonies, and had to interrupt his research work. Taking it up again in 1760, he put up the first effective lightning conductor on the house of a Philadelphia businessman.

His theory was that during a thunderstorm a continual radiation of electricity from the earth through the metal of the lightning-conductor would take place, thus equalizing the different potentials of the air and the earth so that the violent discharge of the lightning would be avoided. The modern theory, however, is that the lightning-conductor simply offers to the electric tension a path of low resistance for quiet neutralization. At any rate – even if Franklin’s theory was wrong – his invention worked.

Yet its general introduction in America and Europe was delayed by all kinds of superstitions and objections: if God warned to punish someone by making the lightning strike his house, how could Man dare to interfere? By 1782, however, all the public buildings in Philadelphia, first capital of the USA, had been equipped with Franklin lightning-conductors, except the French Embassy. In that year this house was struck by lightning and an official killed. Franklin had won the day.

It was he who introduced the idea of “positive” and “negative” electricity, based on the attraction and repulsion of electrified objects. A French physicist, Charles Augustin de Coulomb, studied these forces between charged objects, which are proportional to the charge and the distance between the objects; he invented the torsion balance for measuring the force of electric and magnetic at1raction. In his honor, the practical unit of quantity of electricity was named after him.

To scientists and laymen alike, however, this phenomenon of action at a distance caused by electric and magnetic forces was still rather mysterious. What was it really? In 1780, one of the greatest scientific fallacies of all times seemed to provide the answer. Aloisio Galvani, professor of medicine at Bologna, was lecturing to his students at his home while his wife was skinning frogs, the professor’s favorite dish, for dinner with his scalpel in the adjoining kitchen. As she listened to the lecture the scalpel fell from her hand on to the frog’s thigh, touching the zinc plate at the same time. The dead frog jerked violently as though trying to jump off the plate. The signora screamed. The professor, very indignant about this interruption of his lecture, strode into the kitchen. His wife told him what had happened, and again let the scalpel drop on the frog. Again it twitched.

No doubt the professor was as much perplexed by this occurrence as his wife. But there were his students, anxious to know what it was all about. Galvani could not admit that he was unable to explain the jerking frog. So, probably on the spur of the moment he explained: “I have made a great discovery – animal electricity, the primary source of life”.

“An intelligent woman had made an interesting observation, but the not-so-intelligent husband drew the wrong conclusions, was the judgment of a scientific author a few years later. Galvani made numerous and unsystematic experiments with frogs’ thighs, most of which failed to prove anything at all; in fact, the professor did not know what to look for, except his animal electricity. These experiments became all the rage in Italian society, and everybody talked about galvanic electricity currents – terms which are still in use although Professor Galvani certainly did not deserve the honor.

A greater scientist than he, Alessandro Volta of Pavia, solved the mystery and found the right explanation for the jerking frogs. Far from being the "primary source of life", they played the very modest part of electric conductors while the steel of the scalpel and the zinc of the plate were, in fact, the important things. Volta showed that an electric current begins to flow when two different metals are separated by moisture (the frog had been soaked in salt water), and the frog's muscles had merely demonstrated the presence of the current by contracting under its influence.

Professor Volta went one step further – a most important step, because he invented the first electrical battery, the "Voltaic pile". He built it by using discs of different metals separated by layers of felt which he soaked in acid. A "pile" of these elements produced usable electric current, and for many decades this remained the only practical source of electricity. From 1800, when Volta announced his invention, electrical research became widespread among the world's scientists in innumerable laboratories.

V Translate dialogues, using words and expressions from the text above.

1.

– В наше время люди не представляют себе жизни без электричества. А ведь только в конце 19 века электричество стало играть огромную роль в современной цивилизации.

– Ты прав. Самое удивительное, что внедрил его не учёный, знакомый с теориями и фундаментальными законами природы, а простой техник и очень хороший бизнесмен.

– Ты имеешь в виду Эдисона? Да, он заинтересовался проблемой освещения в 1877 году. К тому времени была изобретена дуговая лампа. Два стержня из углерода, производили электрическую дугу, которая замыкала электрическую цепь. Свет от таких ламп накаливания был слабый, лампочки были недолговечны.

– Эдисон проводил свои эксперименты в лабораториях Менло-Парка. Он искал материал, подходящий для нити накала. Он испытывал различные металлы, бамбуковое волокно, человеческий волос, бумагу. Всё это покрывалось углеродом и вставлялось в стеклянный пузырь, из которого выкачивался воздух, чтобы эти материалы не горели.

– Только подумай, что оторванная пуговица помогла ему найти этот материал – обычную нитку. Его первая лампа горела 40 часов.

2.

– В 1879 году Эдисон изобрёл электрическую лампу накаливания. Это было одно из величайших достижений в истории открытий.

– Вполне согласен с тобой. Эдисон был практиком, и он очень хорошо знал, что внедрение такой революционной системы освещения должно быть хорошо подготовлено. Поэтому он разработал методы для массового производства таких лампочек по низкой цене.

– Именно Эдисон обнаружил, что самая подходящая разница потенциалов должна быть 110/220 вольт, что снизило потери тока при передаче.

– Ты прав. Такое напряжение и сейчас в электросети. Но ведь его надо произвести. А как? И Эдисон построил генератор, который производил необходимый ток.

– До Эдисона пытались построить генератор, основанный на гениальном открытии Фарадея. Но именно Эдисон использовал это изобретение в своём генераторе.

– И он сделал его настолько хорошо, что его система используется и сейчас, за исключением мелких усовершенствований и размера.

3.

– Послушай, а где Эдисон впервые применил свою систему освещения?

– О, это малоизвестный факт. Эдисон поместил свою систему на борту арктического парохода “Жанет”. Система успешно работала два года.

– Хорошо известно, что Эдисон был замечательным шоуменом и великолепным изобретателем. Он осветил свои лаборатории в Менло-Парке 500 лампочек в 1880 году. Это вызвало сенсацию. Инженеры и техники пересекали Атлантику из Европы, чтобы увидеть чудо.

– Неужели у него не было противников? В то время дома и улицы освещались газом.

– Известный берлинский инженер Сименс сказал, что электрический свет никогда не заменит газ. Но в 1881 году Эдисон показал свои лампы впервые на Парижской выставке.

– Эдисон сильно рисковал своими деньгами и репутацией. Чтобы внедрить своё изобретение, он купил место на Перл-стрит в Нью-Йорке, построил 6 больших генераторов постоянного тока в 900 лошадиных сил и осветил 85 зданий. Электрическое освещение получило признание.

4.

– Использование электричества быстро набирало популярность, не так ли?

– Да, конечно. Освещение – это хороший спектакль, но это только один аспект использования электричества.

– Почему же электричество использовалось практически только для освещения?

– В течение века возвратно-поступательный паровой двигатель был единственным источником механической энергии. Но его мощь была ограничена местом, где он работал.

– Насколько я знаю, к тому времени двигатель, который преобразовал электрическую энергию в механическую, уже существовал. Ещё в 1822 году Фарадей описал способ, как должен работать электромотор. Катушка или якорь помещаются между полюсами электромагнита. Когда ток проходит через катушку, электромагнитная сила заставляет её вращаться. Фактически, это обратный способ работы генератора.

– Но никому не приходило в голову, что мотор и генератор можно сделать взаимозаменяемыми. Российский физик Якоби в середине 19 века построил несколько электромоторов. Один он даже установил в своей лодке. Но он пришёл к выводу, что электромотор – не экономичная машина, так как гальваническая батарея была единственным источником энергии.

5.

– Кто изобрёл асинхронный двигатель?

– Насколько я помню, профессор из Турина Феррари и американский инженер Тесла сделали это. На сначала это техническое достижение мало признавали.

– Но это было очень важным достижением! Принцип работы асинхронного двигателя не изменился с тех пор, хотя он был значительно усовершенствован, и его мощность возросла во много раз. Как он устроен?

– Он известен как “беличье колесо”. Два медных или алюминиевых жёстких кольца соединены параллельными стержнями. Это сооружение встроено в медный цилиндр, находящийся на валу, который представляет собой ротор, вращающуюся часть. Неподвижная часть, статор, состоит из множества соединённых между собой электрических проводников, называемых обмоткой.

– Понятно. Но, недостатком этого двигателя была его неизменная скорость. И только в 1959 году исследователям из Бристольского университета удалось построить двигатель с двумя скоростями.

6.

– Учёные постоянно искали надёжный и недорогой источник механической энергии, не так ли?

– Ты прав. Хотя Сименсу удалось подсоединить паровой двигатель и динамо, эта конструкция была неудовлетворительной.

– Интересно, кто же додумался до гидроэлектростанции?

– Мы не знаем. Возможно, эта идея носилась в воздухе. В 1927 году молодой француз сконструировал эффективную водяную турбину, где вода падала на колесо внутри кожуха. Это был прототип современной водяной турбины.

– Если я не ошибаюсь, в Америке была сконструирована водяная турбина с огромными ковшеобразными лопастями. Она была установлена на водопаде. Но не везде есть водопады.

– Конечно. Поэтому были сконструированы турбины для падения воды от 100 до 1000 футов с большим количеством изогнутых лопастей.

7.

– Когда была построена первая гидроэлектростанция?

– Возможно, в 1891 году на Ниагарском водопаде мощностью 5200 лошадиных сил. Эта гидроэлектростанция была первой, которая использовала переменный ток, вырабатываемый при высоком напряжении.

– Если память мне не изменяет, ток высокого напряжения передавать экономичнее, чем низкого. Если напряжение возрастёт в 10 раз, потери электроэнергии при передаче снизятся на 1/100. Поэтому переменный ток можно передавать на большие расстояния.

– Но в конце 19-го века электричество всё ещё было мистическим и пугающим. Кроме того, газовая промышленность пыталась препятствовать его распространению, так как оно могло нарушить монополию газовых компаний в освещении.

– Так оно и произошло. В 1889 году была построена первая электростанция в Лондоне мощностью 10000 вольт, а в 1891 году – в Германии мощностью 16000 вольт.

UNIT III

PRINCIPLES OF ELECTRICITY

I. Recognize the following international words:

electrical, material, resistor, orbit, electron, atom, electronics, diode, transistor, laser, equivalent, potential, energy, voltage, analogous, battery, generator, ampere.

II. Memorize the words to be ready to read and speak about principles of electricity.

conductor	проводник
semiconductor	полупроводник
insulator	изолятор, диэлектрик
circuit	цепь, схема
current	ток
alternating current	переменный ток
direct current	постоянный ток
source	источник
to supply	снабжать, снабжение
property	свойство
velocity	скорость
potential difference	разность потенциалов
electromotive force	электродвижущая сила
to measure	измерять
charge	заряд
parallel connection	параллельное соединение
in series	последовательное соединение

III. Decode the following acronyms:

e. m. f.; d. c.; a. c.; p. d.; V; A.

IV. Read and translate the following words and word combinations:

excellent, conductor, current flow, good insulator, semiconductor materials, electrical supply, potential difference, supply source, a measured electromotive force, charge carrier, electrical circuit, series connection, much higher velocity.

V. Use the words and the word combinations from the exercises II and IV in the following sentences:

1… include silicon, germanium and cadmium sulphide.

2. Battery is the simplest …

3. Electrons are negative …

4. Metal is a …

5. Electrical generator produces …

6. The electrical potential between two points in a circuit is known as the …

7. Two types of connections are known in electrical circuit: … and …

8. The voltage which produces the current is known as …

VI. Read and translate the text.

VOLTAGE AND CURRENT

Voltage is the electrical equivalent of mechanical potential. If a person drops a rock from the first storey of a building, the velocity that the rock attains on reaching the ground is fairly small. However, if the rock is taken to the twentieth floor of the building, it has a much greater potential energy and, when it is dropped it reaches a much higher velocity on reaching the ground. The potential energy of an electrical supply is given by its voltage and the greater the voltage of the supply source, the greater its potential to produce electrical current in any given circuit connected to its terminals (this is analogous to the velocity of the rock in the mechanical case). Thus the potential of a 240-volt supply to produce current is twenty times that of a 12-volt supply.

The electrical potential between two points in a circuit is known as the potential difference or p. d. between the points. A battery or electrical generator has the ability to produce current flow in a circuit, the voltage which produces the current being known as the electromotive force (e. m. f.). The term electromotive force strictly applies to the source of electrical energy, but is sometimes (incorrectly) confused with potential difference. Potential difference and e. m. f. are both measured in volts, symbol V.

The current in a circuit is due to the movement of charge carriers through the circuit. The charge carriers may be either electrons (negative charge carriers) or holes (positive charge carriers), or both. Unless stated to the contrary, we will assume conventional current flow in electrical circuit that is we assume that current is due to the movement of positive charge carriers (holes) which leave the positive terminal of the supply source and return to the negative terminal. The current in an electrical circuit is measured in amperes, symbol A, and is sometimes (incorrectly) referred to as “amps”.

A simple electrical circuit comprises a battery of e. m. f. 10 V which is connected to a heater of fixed resistance; let us suppose that the current drawn by the heater is 1 A. If two 10-V batteries are connected in series with one another, the e. m. f. in the circuit is doubled at 20 V; the net result is that the current in the circuit is also doubled. If the e. m. f.is increased to 30 V, the current is increased to 3 A, and so on.

A graph showing the relationship between the e. m. f. in the circuit and the current is a straight line passing through the origin; that is, the current is zero when the supply voltage is zero. This relationship is summed up by Ohm’s law.

VII. Find the sentences in the text about:

a) potential difference;

b) charge carriers;

c) measurements of potential difference and electromotive force;

d) electrical equivalent of mechanical potential;

e) conventional current flow;

f) electromotive force;

g) series connection.

VIII. Answer the questions to the text using the following introductory phrases: as far as I know; I think quite so; it is really; as far as I remember.

1. What is voltage?
2. By what is potential energy of an electric supply given?
3. The electrical potential between two points in a circuit is known as the potential difference, isn't it?
4. What device has the ability to produce current flow in a circuit?
5. In what terms is e. m. f. measured?
6. Why does the current occur in the circuit?
7. May holes be charge carriers?
8. In what terms are current measured?
9. In what law is the relationship between e. m. f. and the current summed up?

IX. Express the main idea of each paragraph of the text "Voltage and Current" in writing. Retell the text using the sentences, expressing the main idea of its paragraphs as a plan, and introductory phrases of exercise VIII.

X. Read and translate the text given below without a dictionary.

CONDUCTORS, SEMICONDUCTORS AND INSULATORS

A conductor is an electrical material (usually a metal) which offers very little resistance to electrical current. The reason that certain materials are good conductors is that the outer orbits (the valence shells) in adjacent atoms overlap one another, allowing electrons to move freely between the atoms.

An insulator (such as glass or plastic) offers a very high resistance to current flow. The reason that some materials are good insulators is that the outer orbits of the atoms do not overlap one another, making it very difficult for electrons to move through the material.

A semiconductor is a material whose resistance is midway between that of a good conductor and that of a good insulator. Commonly used semiconductor materials include silicon and germanium (in diodes, transistors and integrated circuits), cadmium sulphide (in photoconductive cells), gallium arsenide (in lasers, and light-emitting diodes), etc. Silicon is the most widely used material, and it is found in many rocks and stones (sand is silicon dioxide).

XI. Agree or disagree with the following statements using introductory phrases: You are quite right; It is really so; I quite agree with you; That's wrong; On the contrary; I'm afraid you are wrong.

1. A conductor offers very little resistance.
2. Commonly used semiconductor materials are different metals.
3. Conductor materials are usually metals.
4. An insulator offers very little resistance.
5. Semiconductor materials such as silicon and germanium are used in diodes, transistors, integrated circuits.
6. It is very difficult for electrons to move through the material in insulators.

7. A semiconductor resistance is midway between that of a good conductor and that of a good insulator.

8. Electrons move freely between the atoms in semiconductors.

9. Insulator materials are glass and plastic.

XII. Imagine that one of the students is a teacher of electric engineering. The group consults the teacher before the exam. Ask as many questions as you can on both of the texts.

XIII. Dramatize the dialogues.

1.

– Я знаю, что ты учишься на энергетическом факультете. Объясни мне, пожалуйста, что такое проводник и диэлектрик.

– С удовольствием. Проводник – это материал, который оказывает очень маленькое сопротивление электрическому току, то есть проводит ток. А диэлектрик – это материал, который оказывает очень большое сопротивление электрическому току. Практически он ток не проводит.

– Как я понял, полупроводник – это что-то среднее между проводником и диэлектриком. Какой материал может быть хорошим проводником, диэлектриком и полупроводником?

– Металлы – хорошие проводники. Хорошие диэлектрики стекло и пластмассы. Обычно используемые полупроводниковые материалы – это кремнезем, германий, сульфид кадмия.

2.

– Интересно, чем это ты занимаешься?

– Готовлюсь к зачёту по электротехнике. Насколько я помню, ты уже сдал его. Проверь меня, пожалуйста.

– Хорошо. Как зависит электрический ток от напряжения?

– Ну, это просто. Чем больше напряжение источника, тем больший он имеет потенциал для производства тока в цепи.

– Правильно. А что такое разница потенциалов?

– Электрический потенциал между двумя точками в цепи известен как разница потенциалов. А напряжение, которое производит ток, – электродвижущая сила.

– А ток – это жидкость, которая течёт внутри проводов, не так ли?

– Ну, уж нет, ты меня не собьёшь. Ток в цепи появляется благодаря движению положительно заряженных частиц к отрицательно заряженному полюсу.

– Отлично! Интересно, почему же ты не сдал этот зачёт с первого раза.

UNIT IV

ELECTRIC CURRENT

I. Study the words given below; make up sentences with these words.

to be certain	быть уверенным
as well	также, тоже
to consider	рассматривать
to decrease	уменьшать
to determine direct current	измерять постоянный ток
direction	направление
to increase	увеличивать
to appear	появляться
to meet requirements	удовлетворять требованиям
particle	частица
to require statement	требовать констатации
subject	предмет
terminal	клемма
to pass through	проходить через
wire	провод, проволока
solid	твердое вещество
both	оба, обе; и тот и другой

II. Read and translate the text given below.

ELECTRIC CURRENT

Ever since Volta first produced a source of steady continuous current, men of science have been forming theories on this subject. For some time they could see no real difference between the newly-discovered phenomenon and the former understanding of static charges. Then the famous French scientist Ampere (after whom the unit of current was named) determined the difference between the current and the static charges. In addition to it, Ampere gave the current direction: he supposed it to flow from the positive pole of the source round the circuit and back again to the negative pole.

We consider Ampere to be right in his first statement but he was certainly wrong in the second, as to the direction of the current. The student is certain to remember that the flow of current is in a direction opposite to what he thought.

Let us turn our attention now to the electric current itself. The current which flows along wires consists of moving electrons. What can we say about the electron? We know the electron to be a minute particle having an electric charge. We also know that that charge is negative. As these minute charges travel along a wire, that wire is said to carry an electric current.

In addition to traveling through solids, however, the electric current can flow through liquids as well and even through gases. In both cases it produces some most important effects to meet1ndustrial requirements.

Some liquids, such as melted metals for example, conduct current without any change to themselves. Others, called electrolytes, are found to change greatly when the current passes through them.

When the electrons flow in one direction only, the current is known to be d. c., that is, direct current. The simplest source of power for the direct current is a battery, for a battery pushes the electrons in the same direction all the time (i.e., from the negatively charged terminal to the positively charged terminal).

The letters a. c. stand for alternating current. The current under consideration flows first in one direction and then in the opposite one. The a. c. used for power and lighting purposes is assumed to go through 50 cycles in one second.

One of the great advantages of a. c. is the ease with which power at low voltage can be changed into an almost similar amount of power at high voltage and vice versa. Hence, on the one hand alternating voltage is increased when it is necessary for long-distance transmission and, on the other hand, one can decrease it to meet industrial requirements as well as to operate various devices at home.

Although there are numerous cases when d. c. is required, at least 90 per cent of electrical energy to be generated at present is a. c. A. c. finds wide application for lighting, heating, industrial, and some other purposes.

One cannot help mentioning here that Yablochkov, Russian scientist and inventor, was the first to apply a. c. in practice.

III. Translate the following sentences and define the infinitive constructions.

1. Lightning proved to be a discharge of electricity.
2. The student is certain to know that alternating voltage can be increased and decreased.
3. Heat is known to be a form of energy.
4. We know the electrons to flow from the negative terminal of the battery to the positive one.
5. This scientist seems to have been working on the problem of splitting the atom.
6. The students saw the thermometer mercury fall, to the fixed point.
7. Coal is considered to be a valuable fuel.
8. We know many articles to have already been written on that subject.
9. The electrolytes appear to change greatly when the current passes through them.

IV. Find the infinitive constructions in the text and define them.

V. According to the models given below form sentences combining suitable parts of the sentence given in column I, II, III, IV.

Model: (a) The current is known to consist of moving electrons.

I	II	III	IV
Professor Rihman	was observed	to have started	by man 25 centuries ago.
Amber	is known	to have been observed	for Moscow on foot.
Lomonosov	is said	to have been killed	light objects after rubbing.
Electrical effects	is known	to attract and to hold	in English-speaking countries.
The Fahrenheit scale	are known	to be used	by a stroke of lightning.

Model: (b) We know lightning to be a discharge of electricity.

I	II	III	IV
We know	Galileo the charges the electric current the alternating current the Russian scientists static electricity	to be to have invented to flow to produce to have been to have greatly contributed	positive and negative. important effects. an air thermometer. first in one direction and then in another. to the science of electricity. the only electrical phenomenon observed by man.

VI. Translate the following sentences using the infinitive.

1. Чтобы быть хорошим инженером, необходимо много читать и учиться.

2. Пирометр используется для измерения температуры горячих металлов.

3. Человек научился расщеплять атомы для того, чтобы получить большое количество энергии.

4. Учёные пытаются решить проблему, связанную с новыми явлениями электричества.

5. Громоотвод – металлическое приспособление для защиты зданий от молний.

6. Проводить опыты с атмосферным электричеством было очень опасно в то время.

7. Намагнитить предмет – это значит поместить в его поле магнит.

VII. Ask questions.

1. if electricity is a form of energy.
2. if there are two types of electricity.
3. if alternating voltage can be increased and decreased.
4. if Franklin made an important contribution to the science of electricity.
5. if Ampere determined the difference between the current and the static charges.
6. if the electric current can flow through liquids and through gases.
7. if the electrolytes change greatly when the current passes through them.
8. if a negatively charged electron will move to the positive end of the wire.

VIII. Explain why.

1. static electricity cannot be used to light lamps, to boil water, to run electric trains and so on.

2. voltage is increased and decreased.

3. the unit of electric pressure is called the volt.

4. students must learn English.

5. Ampere was wrong as to the current direction.

6. the current is said to flow from the positive end of the wire to its negative end.

IX. The following statements are not true to the fact. Correct them.

1. Electrons flow from the positively charged terminal of the battery to the negatively charged terminal.

2. Ampere supposed the current to flow from the negative pole to the positive.

3. Static electricity is used for practical purposes.

4. Static electricity is not very high in voltage and it is easy to control it.

5. To show that the charges are unlike and opposite Franklin decided to call the charge on the rubber positive and that on the glass negative.

6. Galvani thought that electricity was generated because of the contact of the two dissimilar metals used.

7. Volta took great interest in atmospheric electricity and began to carryon experiments.

8. The direct current is known to flow first in one direction and then in the opposite one.

9. The direct current used for power and lighting purposes is assumed to go through 50 cycles a second.

X. Give a heading to each paragraph of the text. Explain why you have given such a heading.

XI. Give a short summary of the text.

XII. Form six sentences combining suitable parts of the sentence given in the columns.

1. The electric current is …	a. the energy of position.
2. Kinetic energy is …	b. electricity at rest.
3. Static electricity is …	c. the flow of moving electrons.
4. Potential energy is …	d. the energy of motion.
5. The direct current is …	e. a discharge of electricity.
6. Lightning is …	f. the flow of electrons in one direction.

XIII. Read additional texts.

TYPES OF ELECTRIC CURRENT

An electric current may be produced in a variety of ways, and from a number of different types of apparatus, e.g. an accumulator, a d. c. or an a. c. generator, or a thermionic valve. Whatever the source of origin, the electric current is fundamentally the same in all cases, but the manner in which it varies with time may be very different. This is shown by the graph of the current plotted against time as a base, and a number of examples are illustrated in Fig. 1.

(a) represents a steady direct current (D.C.) of unvarying magnitude, such as is obtained from an accumulator.

(b) represents a D.C. obtained from a d. c. generator, and consists of a steady D.C. superimposed on which is a uniform ripple of relatively high frequency, due to the commutator of the d. c. generator. As the armature rotates the commutator segments come under the brush in rapid succession and produce a ripple in the voltage which is reproduced in the current.

(c) represents a pulsating current varying periodically between maximum and minimum limits. It may be produced by adding a D.C. to an A.C. or vice versa. The d. c. component must be the larger if the current is to remain unidirectional. All the first three types, of current are unidirectional, i.e. they flow in one direction only.

(d) represents a pure alternating current (A.C.). The current flows first in one direction and then in the other in a periodic manner, the time of each alternation being constant. In the ideal case the current varies with time according to a sine law, when it is said to be sinusoidal. Considering the time of a complete cycle of current (a positive half-wave plus a negative half-wave) as equal to 360°, the instantaneous values of the current are proportional to the sine of the angle measured from the zero point where the current is about to rise in the positive direction*.

(e) represents a type of A.C. with a different wave form. Such an A.C. is said to have a peaked wave form, the term being self-explanatory.

(f) represents an A.C. with yet another different wave form. Such an A.C. is said to have a flat-topped wave form, the term again being self-explanatory. Both this and the previous example represent cases of A.C. having non-sinusoidal wave forms.

(g) represents an example of an oscillating current, and is similar in shape to (d) except that it has a much higher frequency. An oscillating current is usually regarded as one having a frequency determined by the constants of the circuit, whereas an alternating current has a frequency determined by the apparatus supplying the circuit.

(h) represents another type of oscillating current which is known as damped. The current again has a constant frequency, but its amplitude is damped, i.e. it dies down, after which it is brought back to its original value.

(i) represents yet another type of oscillating current, this time known as a modulated current. The amplitude varies rhythmically between maximum and minimum values. It may even die down to zero.

(j) The next three examples represent various types of transient currents. These transient currents usually die away extremely rapidly, and times** are generally measured in microseconds. The first example shows a current dying away to zero, and is an example of a unidirectional transient. Theoretically it takes an infinite time to reach absolute zero.

(k) represents a simple a. c. transient. The current gradually dies down to zero as in the previous case, but this time it is an A.C. that is dying away.

(l) represents a peculiar, but not uncommon, type of a. c. transient. The current is initially unidirectional, but it gradually becomes an ordinary A.C. The positive half waves die away much more rapidly than the negative half-waves grow, so that the final amplitude is very much reduced.

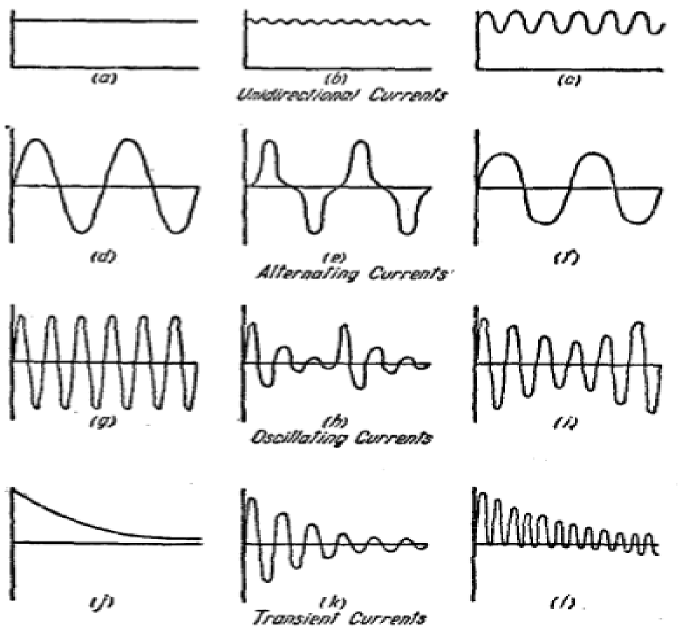

Fig. 1. Types of Electric Current.

The above examples do not represent all the types of current encountered, but they serve as illustrations of what may be expected. It will be observed that in all the above cases the current consists of either or both unidirectional and alternating components***. In modern electrical engineering alternating currents play a predominant part, so that knowledge of the a. c. circuit is of basic importance.

* where the current is about to rise in the positive direction где ток должен начать возрастать в положительном направлении; (to) be about to собираться (делать ч. л.)

** times зд. *периоды затухания*

*** in all the above cases the current consists of either or both unidirectional and alternating components во всех вышеуказанных случаях ток состоит или из тока одного направления, или из знаков переменного тока, или из того и другого вместе. Above в функции определения переводится «вышеуказанный, вышеупомянутый». Местоимение either здесь имеет значение *любой*, *один из двух*, но не *оба*

DIFFERENCE BETWEEN A.C. AND D.C.

A direct current (D.C.) flows continuously through a conducting circuit in one direction only, although it may not be steady so far as magnitude is concerned. It is unidirectional in character. An alternating current (A.C.), on the other hand, continually reverses in direction, as its name implies. Starting from zero, it grows in one direction, reaches a maximum, dies down to zero again, after which it rises in the opposite direction, reaches a maximum, again dying down to zero. It is thus continually changing in magnitude as well as direction, and this continual change causes certain effects of far-reaching importance.

It can be shown that high voltages are desirable for the economic transmission of a given amount of electric power. Take, for example, the transmission of 1000 kW. If the transmission voltage is 100 volts the current must be 10,000 amperes, but if the transmission voltage is 10,000 volts the current is only 100 amperes. The cross section of the cables transmitting the power is determined by the current to be carried, and so in the former case the cables would need to be very much larger than in the latter case. It is true that the high-voltage cable would need to have more insulation, but even so, it would be very much cheaper than the larger low-voltage cable. A high voltage is therefore essential for the economic transmission of electric power. Again, a. c. generators can be designed and built for much higher voltages than can d. c. generators, the voltage of the latter being limited by the problem of sparking at the commutator, a component which is absent in the a. c. generator. Then there is the most important factor that it is easy to transform a. c. power from one voltage to another by means of the transformer, an operation that is denied to the d. c. system.

The transformer also enables the voltage to be stepped down at the receiving end of the transmission line to values which can readily be used by the various consumers. If necessary, it can be converted to the d. c. form for actual use, although this is not often necessary. There are certain processes for which D.C. is either essential or at any rate desirable but the utilization of electric power in the a. c. form is growing steadily. At the present day, by far the greater part* of the generation, transmission, and utilization of electric power is carried out by means of A.C.

* by far the greater part значительно большая часть; by far употребляется перед сравнительной степенью прилагательного для усиления его значения

UNIT V

BATTERIES AND OTHER SOURCES OF E. M. F.

I. Recognize the following international words:

chemical, effect, electric, industry, electrode, anode, cathode, electrolyte, material, battery, category, accumulator, limit, resistor, function, employ, construction, instrument, electrostatic, voltmeter, wattmeter.

II. Memorize the words to be ready to read and speak about batteries and other sources of e. m. f.

to electroplate	наносить покрытие гальваническим способом
cell (storage)	элемент (аккумуляторный)
plate	пластина, анод
to immerse	погружать
reverse	переключение, изменение полярности
resistor	сопротивление, реостат
magnitude	величина
thermocouple	термопара, термоэлемент
to pilot	центровать
bearing	подшипник, опора
taut	упругий
air-vane damping	пневматическое затухание
armature	сердечник, якорь
fuse	плавкий предохранитель
trip	механизм для авто выключения
slug	сердечник
to deflect	отклонять
to ensure	гарантировать

to wound	наматывать, виток
eddy current	вихревой ток
dashpot	масляный буфер
drag	здесь–сопротивление

III. Read and translate the following word combinations:

electroplating industry; electrochemical effect; primary cell; secondary or storage cell; moist electrolyte; reversible chemical action; fixed resistor; variable resistor; analogue instruments; digital instruments; thermocouple instruments; a deflecting force; a controlling force; a damping force; permanent magnet; taut metal band; small section wire; iron armature; magnetic pull.

IV. Use the word combinations given above in the following sentences.

1. All the … depend on the electrolyte.
2. … can be recharged.
3. A dry cell has a …
4. Rechargeable cells are often connected in series to form a …
5. When current is passed through cells of the battery in the reverse direction they have a …
6. There are two types of resistors: …, … and …
7. Instruments are classified as … and …
8. The effect of heat produced by a current in a conductor is used in …
9. The moving coil is situated in the magnetic field produced by a …
10. The "voltage" coil has many turns of …

V. Read and translate the text without a dictionary.

ELECTROCHEMICAL EFFECT

The chemical effect of an electric current is the basis of the electroplating industry; the flow of electric current between two electrodes (one being known as the anode and the other as the cathode) in a liquid (the electrolyte) causes material to be lost from one of the electrodes and deposited on the other.

The converse is true, that is, chemical action can produce an e. m. f. (for example, in an electric battery).

All these electrochemical effects depend on the electrolyte. The majority of pure liquids are good insulators (for example, pure water is a good insulator), but liquids containing salts will conduct electricity. You should also note that some liquids such as mercury (which is a liquid metal) are good conductors.

VI. Find in the text "Electrochemical effect" sentences about:

a) the flow of electric current between two electrodes;

b) liquids which are good conductors;

c) liquids which are good insulators;

d) electroplating industry;

e) products of chemical action;

f) dependence of electrochemical effects on the electrolytes.

VII. Explain electrochemical effect to your partner using the following key words:

chemical effect; electroplating industry; the anode; the cathode; liquid; cause; to be lost from; to be deposited.

VIII. Read the texts given below.

CELLS AND BATTERIES

A cell contains two plates immersed in an electrolyte, the resulting chemical action in the cell producing an e. m. f. between the plates. Cells can be grouped into two categories. A primary cell cannot be recharged and, after the cell is "spent" it must be discarded (this is because the chemical action inside the cell cannot be "reversed"). A secondary cell or storage cell can be recharged because the chemical action inside it is reversed when a "charging" current is passed through it.

Cells are also subdivided into "dry" cells and "wet" cells. A dry cell is one which has a moist electrolyte, allowing it to be used in any physical position (an electric torch cell is an example). A wet cell is one which has a liquid electrolyte which will spill if the cell is turned upside down (a cell in a conventional lead-acid auto battery is an example). There is, of course, a range of sealed rechargeable cells which are capable of being discharged or charged in any position; the electrolyte in these cells cannot be replaced.

A battery is an interconnected group of cells (usually connected in series) to provide either a higher voltage and/or a higher current than can be obtained from one cell.

STORAGE BATTERIES

Rechargeable cells are often connected in series to form a storage battery, a car battery being an example; a storage battery is frequently called an accumulator. The cells of the battery have a reversible chemical action and, when current is passed through them in the "reverse" direction (when compared with the discharging state); the original material of the electrodes is re-formed. This allows the battery to be repeatedly discharged and charged.

RESISTOR TYPES

A resistor is an element whose primary function is to limit the flow of electrical current in a circuit. A resistor is manufactured either in the form of a fixed resistor or a variable resistor, the resistance of the latter being alterable either manually or electrically. Many methods are employed for the construction of both fixed and variable resistors.

IX. Answer the following questions using the introductory phrases: I should say; to my mind; as far as I know (remember); certainly; if I'm not mistaken.

1. What does each cell contain?
2. What two categories of cells are there?
3. Can a primary cell be recharged?
4. Why must it be discarded?
5. Why can a secondary cell be recharged?
6. What is the difference between a dry cell and a wet cell?
7. What device do we call a battery?
8. What device do rechargeable cells form when they are connected in series? How does it work?
9. What is the function of a resistor?

X. Using the above introductory phrases speak about:

a) primary and secondary cells;

b) dry and wet cells;

c) batteries and storage batteries;

d) resistors.

XI. Translate the text. Prepare questions to be answered.

TYPES OF INSTRUMENTS

Instruments are classified as either analogue instruments or digital instruments. An analogue instrument is the one in which the magnitude of the measured electrical quantity is indicated by the movement of a pointer across the face of a scale. The indication on a digital instrument is in the form of a series of numbers displayed on a screen; the smallest change in the indicated quantity corresponding to a change of ˆ1 digit in the least significant digit (l.s.d.) of the number. That is, if the meter indicates 10.23 V, then the actual voltage lies in the range from 10.22 V to 10.24 V. Both types of instrument have their advantages and disadvantages, and the choice of the best instrument depends on the application you have in mind for it. As a rough guide to the features of the instruments, the following points are useful:

a) an analogue instrument does not (usually) need a battery or power supply;

b) a digital instrument needs a power supply (which may be a battery);

c) a digital instrument is generally more accurate than an analogue instrument (this can be a disadvantage in some cases because the displayed value continuously changes as the measured value changes by a very small amount);

d) both types are portable and can be carried round the home or factory.

A GALVANOMETER OR MOVING-COIL INSTRUMENT

A galvanometer or moving-coil instrument depends for its operation on the fact that a current-carrying conductor experiences a force when it is in a magnetic field. The "moving" part of the meter is a coil wound on an aluminium former or frame which is free to rotate around a cylindrical soft-iron core. The moving coil is situated in the magnetic field produced by a permanent magnet; the function of the soft-iron core is to ensure that the magnetic field is uniformly distributed. The soft-iron core is securely fixed between the poles of the permanent magnet by means of a bar of non-magnetic material.

The moving coil can be supported either on a spindle which is pivoted in bearings (often jewel bearings) or on a taut metal band (this is the so-called pivot less suspension). The current enters the “moving” coil from the terminal either via a spiral hairspring or via the taut band mentioned above. It is this hairspring (or taut band) which provides the controlling force of the instrument. The current leaves the moving coil either by another hairspring or by the taut band at the opposite end of the instrument.

When current flows in the coil, the reaction between each current-carrying conductor and the magnetic field produces a mechanical force on the conductor; this is the deflecting force of the meter.

This force causes the pointer to be deflected, and as it does so the movement is opposed by the hairspring which is used to carry current into the meter. The more the pointer deflects, the greater the controlling force produced by the hairspring.

Unless the moving system is damped, the pointer will overshoot the correct position; after this it swings back towards the correct position. Without damping, the oscillations about the correct position continue for some time. However, if the movement is correctly damped, the pointer has an initial overshoot of a few per cent and then very quickly settles to its correct indication. It is the aim of instrument designers to achieve this response.

Damping is obtained by extracting energy from the moving system as follows. In the moving-coil meter, the coil is wound on an aluminium former, and when the former moves in the magnetic field of the permanent magnet, a current (known as an eddy current) is induced in the aluminium former. This current causes power to be consumed in the resistance of the coil former, and the energy associated with this damps the movement of the meter.

REQUIREMENTS OF ANALOGUE INSTRUMENTS

Any instrument which depends on the movement of a pointer needs three forces to provide proper operation. These are:

a) a deflecting force;

b) a controlling force;

c) a damping force.

The deflecting force is the force which results in the movement or deflection of the pointer of the instrument. This could be, for example, the force acting on a current-carrying conductor which is situated in a magnetic field.

The controlling force opposes the deflecting force and ensures that the pointer gives the correct indication on the scale of the instrument. This could be, for example, a hairspring. The damping force ensures that the movement of the pointer is damped: that is, the damping force causes the pointer to settle down, that is, be “damped”, to its final value without oscillation.

EFFECTS UTILISED IN ANALOGUE INSTRUMENTS

An analogue instrument utilizes one of the following effects:

a) electromagnetic effect;

b) heating effect;

c) electrostatic effect;

d) electromagnetic induction effect;

e) chemical effect.

The majority of analogue instruments including moving-coil, moving-iron and electrodynamic (dynamometer) instruments utilize the magnetic effect. The effect of the heat produced by a current in a conductor is used in thermocouple instruments. Electrostatic effects are used in electrostatic voltmeters. The electromagnetic induction effect is used, for example, in domestic energy meters. Chemical effects can be used in certain types of ampere-hour meters.

WATTMETERS

As the name of this instrument implies, its primary function is to measure the power consumed in an electrical circuit. The wattmeter described here is called an electrodynamic wattmeter or a dynamometer wattmeter. It has a pair of coils which are fixed to the frame of the meter (the fixed coils) which carry the main current in the circuit (and are referred to as the current coils), and a moving coil which is pivoted so that it can rotate within the fixed coils. The moving coil generally has a high resistance to which the supply voltage is connected and is called the voltage coil or potential coil. The pointer is secured to the spindle of the moving coil.

Dynamometer wattmeters can measure the power consumed in either a d. c. or an a. c. circuit.

Hairsprings are used to provide the controlling force in these meters, and air-vane damping is used to damp the movement.

The power consumed by a three-phase circuit is given by the sum of the reading of two wattmeters using what is known as the two wattmeter method of measuring power.

THE ENERGY METER OR KILOWATT-HOUR METER

The basic construction of an electrical energy meter is known as an induction meter. This type of meter is used to measure the energy consumed in houses, schools, factories, etc.

The magnetic field in this instrument is produced by two separate coils. The “current” coil has a few turns of large section wire and carries the main current in the circuit. The “voltage” coil has many turns of small section wire, and has the supply voltage connected to it. The “deflection” system is simply an aluminium disc which is free to rotate continuously (as you will see it do if you watch your domestic energy meter), the disc rotating faster when more electrical energy is consumed.

The effect of the magnetic field produced by the coils is to produce a torque on the aluminium disc, causing it to rotate. The more current the electrical circuit carries, the greater the magnetic flux produced by the “current” coil and the greater the speed of the disc; the disc stops rotating when the current drawn by the circuit is zero.

The disc spindle is connected through a set of gears to a “mileometer”-type display in the case of a digital read-out meter, or to a set of pointers in some older meters. The display shows the total energy consumed by the circuit.

The rotation of the disc is damped by means of a permanent magnet as follows. When the disc rotates between the poles of the permanent magnet, a current is induced in the rotating disc to produce a “drag” on the disc which damps out rapid variations in disc speed when the load current suddenly changes.

These meters are known as integrating meters since they “add up” or “integrate” the energy consumed on a continual basis.

XII. Present your abstract of the information from the texts given above.

XIII. Read the text.

APPLICATION OF ELECTROMAGNETIC PRINCIPLES

A basic application with which everyone is familiar is the electric bell. Initially, when the contacts of the bell push are open, the spring on the iron armature of the bell presses the “moving” contact to the “fixed” contact. When the bell push is pressed, the electrical circuit is complete and current flows in the bell coils, energizing the electromagnet. The magnetic pull of the electromagnet is sufficiently strong to attract the iron armature against the pull of the spring so that the electrical connection between the fixed and moving contacts is broken, breaking the circuit.

However, the armature is attracted with sufficient force to cause the hammer to strike the gong. Now that the circuit is broken, the pull of the electromagnet stops, and the leaf-spring causes the armature to return to its original position. When it does so, the circuit contact between the fixed and moving contacts is "made" once more, causing the electromagnet to be energized and the whole process repeated. Only when the bell push is released is the current cut off and the bell stops ringing.

As described earlier, the release of inductive energy when the fixed and moving contacts separate gives rise to a spark between the two contacts. The relay is another popular application of electromagnetism. The relay is a piece of equipment which allows a small value of current, I-1 in the coil of the relay to switch on and off a larger value of current I-2, which flows through the relay contacts.

The control circuit of the relay contains the relay coil and the switch S, when S is open, the relay coil is de-energized and the relay contacts are open (that is, the relay has normally open contacts). The contacts of the relay are on a strip of conducting material which has a certain amount of "springiness" in it; the tension in the moving contact produces a downward force which, when transferred through the insulating material keeps the iron armature away from the polepiece of the electromagnet.

When switch S is closed, current I-1 flows in the relay coil and energizes the relay. The force of the electromagnet overcomes the tension in the moving contact, and forces the moving contact up to the fixed contact. This completes the electrical circuit to the motor, allowing current I-2 to flow in the load.

You might ask why switch S cannot be used to control the motor directly! There are many reasons for using a relay, the following being typical:

1. The current I-1 flowing in the relay coil may be only a few milliamperes, and is insufficient to control the electrical load (in this case a motor which may need a large current to drive it). Incidentally, the switch S may be, in practice, a transistor which can only handle a few milliamperes.

2. The voltage in the control circuit may not be sufficiently large to control the load in the main circuit.

3. There may be a need, from a safety viewpoint, to provide electrical isolation between I-1 and I-2 (this frequently occurs in hospitals and in the mining and petrochemical industries).

Once again, there may be a need to protect the contacts of switch S against damage caused by high induced voltage in the coil when the current I-1 is broken. For this purpose there is a method of connecting a flywheel diode across the relay coil.

Yet another widely-used application of the electromagnetic principle is to provide the overcurrent protection of electrical equipment. You will be aware of the use of the fuse for electrical protection but in industry, this can be a relatively expensive method of protecting equipment (the reason is that once a fuse is "blown" it must be thrown away and replaced by a new one). Industrial fuses tend to be much larger and more expensive than domestic fuses.

In industry, fuses are replaced, where possible, by electromagnetic overcurrent trips. The current from the power supply is transmitted to the load via a contactor (which has been manually closed by an operator) and an over-current trip coil. This coil has a non-magnetic rod passing through it which is screwed into an iron slug which just enters the bottom of the overcurrent trip coil; the iron slug is linked to a piston which is an oil-filled cylinder or dashpot.

At normal values of load current, the magnetic pull on the iron slug is insufficient to pull the piston away from the drag of the oil, and the contacts of the contactor remain closed.

When an overcurrent occurs (produced by, say, a fault in the load) the current in the circuit rises to a value which causes the magnetic pull produced by the trip-coil to overcome the drag of the oil on the piston. This causes the rod and plunger to shoot suddenly upwards; the top part of the rod hits the contactor and opens the contact to cut off the current to the load. In this way the equipment is protected against overcurrent without the need for a fuse.

The value of the tripping current can be mechanically adjusted by screwing the cylinder and iron slug either up or down to reduce or to increase, respectively, the tripping current.

XIV. Present your rendering of the text "Application of electromagnetic principles".

UNIT VI

ELECTRICAL GENERATORS AND POWER DISTRIBUTION

I. Recognize the following international words:

national, electricity, system, generator, magnet, rotor, fix, stator, machine, positive, voltage, phase, turbine, transformer.

II. Memorize the words and word combinations.

alternator	генератор переменного тока
loop	контур, виток
winding	обмотка
instant	момент
bulb	лампочка
to distribute	распределять
slot	прорезь, щель, канавка
iron circuit	магнитная цепь в железе
sinewave	волна синуса
waveform	форма волны
to excite	возбуждать
commutator	коллектор, переключатель
to rectify	выпрямлять
shaft	вал
slip ring	контактное кольцо
brush	щётка
grid	энергетическая система

III. Find Russian equivalents of the word combinations given in the left column.

1. rotating magnet	a) виток провода
2. cable capacitance	b) катушка с одним витком
3. single loop coil	c) магнитная цепь
4. stator winding	d) ёмкость кабеля
5. turn of wire	e) контактное кольцо
6. iron circuit	f) вращающийся магнит
7. armature conductor	g) падение напряжения
8. slip ring	h) потеря энергии
9. voltage drop	i) проводник сердечника
10.power loss	j) обмотка статора

IV. Compose your own sentences using the above word combinations.

V. Read and translate the text given below. Pay special attention to the operating principles of alternators and a. c. generators.

ALTERNATORS OR A.C. GENERATORS

The national electricity supply system of every country is an alternating current supply; in the United Kingdom and in Europe the polarity of the supply changes every V50 s or every 20 ms, and every l/60s or 16.67 ms in the United States of America.

The basis of a simple alternator is the following one. It comprises a rotating permanent magnet (which is the rotating part or rotor**)** and a single-loop coil which is on the fixed part or the stator of the machine. You will see that at this instant of time, current flows into terminal A and out of terminal B (that is, terminal B is positive with respect to A so far as the external circuit is concerned).

When the magnet has rotated through 180A, the S-pole of the magnet passes across conductor A and the N-pole passes across conductor B. The net result at this time is that the induced current in the conductors is reversed when compared with the previous case. That is, terminal B is negative with respect to A.

In this way, alternating current is induced in each turn of wire on the stator of the alternator. In practice a single turn of wire can neither have enough voltage induced in it nor carry enough current to supply even one electric light bulb with electricity.

A practical alternator has a stator winding with many turns of wire on it, allowing it to deal with high voltage and current. The winding in such a machine is usually distributed around the stator in many slots in the iron circuit. The designer arranges the coil design so that the alternator generates a voltage which follows a sine wave, that is, the voltage waveform is sinusoidal.

VI. Write out the key words which you think will help you to describe the basis of a simple alternator.

VII. Describe the basis of a simple alternator, using the key words.

VIII. Read and translate the text.

DIRECT CURRENT GENERATORS

A direct current (d. c.) power supply can be obtained by means of a generator which is generally similar to the alternator, the difference between the a. c. and d. c. generators being the way in which the current is collected from the rotating conductors.

Basically, a d. c. generator consists of a set of conductors on the rotating part or armature of the d. c. machine, which rotate in the magnetic-field system which is on the fixed part or frame of the machine.

Each armature conductor alternately passes an N-pole then an S-pole, so that each conductor has an alternating voltage induced in it.

However, the current is collected from the conductors by means of a commutator consisting of a cylinder which is divided axially to give two segments which enable the alternating current in the conductors to be commutated or rectified into direct current in the external circuit. The way the commutator works is described below.

For example, the conductor WX is connected to the lower segment of the commutator, and the conductor YZ is connected to the up-per segment. At the instant of time shown, the e. m. f.in the armature causes current to flow from W to X and from Y to Z; that is, current flows out of the upper commutator segment and into the lower commutator segment.

IX. Formulate the main idea of each passage.

X. Using your notes as a plan describe the structure and operating principles of a d. c. generator.

XI. Using the key words and your plan make up a dialogue with your partner about structure and operating principles of a. c. and d. c. generators.

XII. Translate the text without a dictionary.

ELECTRICITY GENERATING STATION

The basis of an electrical generating plant is the following one. The power station is supplied with vital items such as water and fuel (coal, oil, nuclear) to produce the steam which drives the turbine round (you should note that other types of turbine such as water power and gas are also used). In turn, the turbine drives the rotor of the alternator round. The rotor of the alternator carries the field windings which are excited from a d. c. generator (which is mechanically on the same shaft as the alternator) via a set of slip rings and brushes.

The stator of the alternator has a three-phase winding on it, and provides power to the transmission system. The voltage generated by the alternator can, typically, be 6600 V, or 11000 V, or 33000 V.

XIII. Ask your partner questions on the basis of an electrical generating plant.

XIV. Answer your partner's questions on the basis of electrical generating plant.

XV. Translate texts given below in written form.

THE A.C. ELECTRICAL POWER DISTRIBUION SYSTEM

One advantage of an a. c. supply when compared with a d. c. supply is the ease with which the voltage level at any point in the system can be "transformed" to another voltage level.

In its simple terms, electrical power is the product of voltage and current and, if the power can be transmitted at a high voltage, the current is correspondingly small. For example, if, in system A, power is transmitted at 11 kV and, in system B, it is transmitted at 33 kV then, for the same amount of power transmitted, the current in system A is three times greater than that in system B. However, the story does not finish there because:

a) the voltage drop in the transmission lines is proportional to the current in the lines;

b) the power loss in the resistance of the transmission lines is proportional to $(\text{current})^2$ [remember, power loss = $I^2 R$].

Since the current in system A is three times greater than the current in system B, the voltage drop in the transmission lines in system A is three times greater than that in system B, and the power loss is nine times greater!

This example illustrates the need to transmit electrical power at the highest voltage possible. Also, since alternating voltages can easily be transformed from one level to another, the reason for using an a. c. power system for both national and local power distribution is self-evident.

D.C. POWER DISTRIBUTION

For certain limited applications, power can be transmitted using direct current. The advantages and disadvantages of this when compared with a. c. transmission are listed below.

Advantages:

1. A given thickness of insulation on cables can withstand a higher direct voltage than it can withstand alternating voltage, giving a smaller overall cable size for d. c. transmission.

2. A transmission line has a given cable capacitance and, in the case of an a. c. transmission system this is charged continuously. In the case of d. c. transmission system, the charging current only flows when the line is first energized.

3. The self-inductance of the transmission line causes a voltage drop when a. c. is transmitted; this does not occur when d. c. is transmitted.

Disadvantages:

1. Special equipment is needed to change the d. c. voltage from one level to another, and the equipment is very expensive.

2. D. c. transmission lends itself more readily to "point-to-point" transmission, and problems arise if d. c. transmission is used on a system which is "tapped" at many points (as are both the national grid system and the local power distribution system).

Clearly, d. c. transmission is financially viable on fairly long "point-to-point" transmission systems which have no "tapping" points.

Practical examples of this kind of transmission system include1 the cross-channel link between the UK grid system and the French grid system via a d. c.

undersea cable link. A number of islands throughout the world are linked either to the mainland or to a larger island via a d. c. undersea cable link. In any event, power is both generated and consumed as alternating current, the d. c. link being used merely as a convenient intermediate stage between the generating station and the consumer.

XVI. Prepare reports about:

a) the a. c. power distribution system;

b) the d. c. power distribution system.

UNIT VII

TRANSFORMERS

I. Translate the active words and expressions given below; make up sentences with them.

to damage
induction coil
input
local
maintenance
negligible
output
to point out
primary
process
secondary
to step down
to step up
whole
winding

II. Read and translate the text.

TRANSFORMERS

The transformer is a device for changing the electric current from one voltage to another. As a matter of fact, it is used for increasing or decreasing voltage. A simple transformer is a kind of induction coil. It is well known that in its usual form it has no moving parts. On the whole, it requires very little maintenance provided it is not misused and is not damaged by lightning.

We may say that the principal parts of a transformer are: two windings, that is coils, and an iron core. They call the coil which is supplied with current the "primary winding", or just "primary", for short. The winding from which they take the current is referred to as the "secondary winding" or "secondary", for short. It is not new to you that the former is connected to the source of supply, the latter being connected to the load.

When the number of, turns of wire on the secondary is the same as the number on the primary, the secondary voltage is the same as the primary, and we get what is called a "one-to-one" transformer. In case, however, the number of turns on the secondary winding is greater than those on the primary, the output voltage is larger than the input voltage and the transformer is called a step-up transformer. On the other hand, the secondary turns being fewer in number than the primary, the transformer is known as a step-down transformer.

The transformer operates equally well to increase the voltage and to reduce it. By the way, the above process needs a negligible quantity of power. It is important to point out that the device under consideration will not work on d.c. but it is rather often employed in direct-current circuits.

Figure 2 shows how transformers are used in stepping up the voltages for distribution or transmission over long distances and then in stepping these voltages down. In this figure, one may see three large step-up transformers which are used to increase the potential to 275,000 volts for transmission over long-distance transmission lines. At the consumer's end of the line, in some distant locality, three step-down transformers are made use of to reduce that value (i.e., 275,000 volts) to 2,300 volts. Local transformers, in their turn, are expected to decrease the 2,300 volts to lower voltages, suitable for use with small motors and lamps. One could have some other transformers in the system that reduce the voltage even further. All radio sets and all television sets are known to use two or more kinds of transformers.

These are familiar examples showing that electronic equipment cannot do without transformers. The facts you have been given above illustrate the wide use of transformers and their great importance.

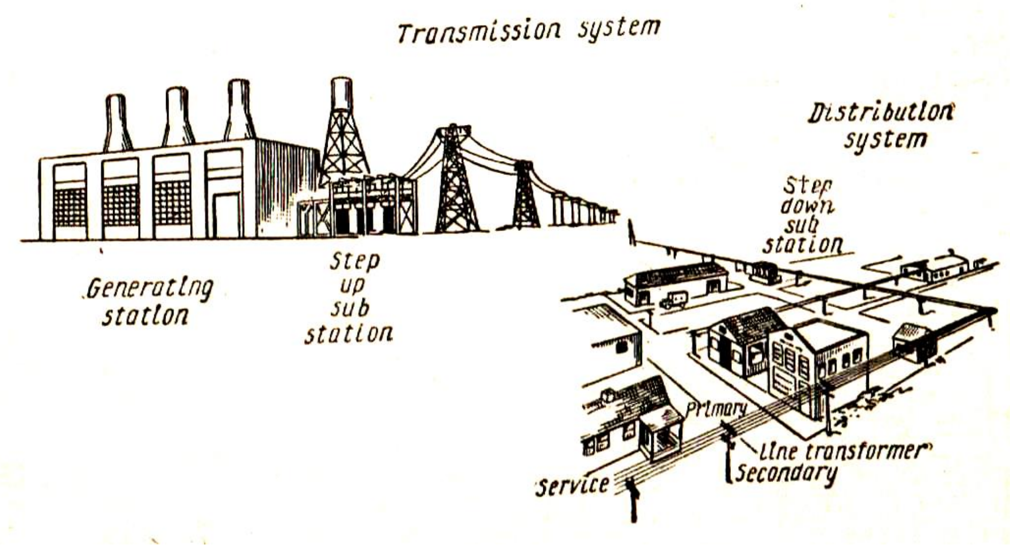

Fig. 2. The use of transformers for many different purposes in transmission and distribution systems.

Another alternating-current system of transmission and distribution is shown in Fig. 3. You are asked to follow the whole process, that is, to describe it from beginning to end.

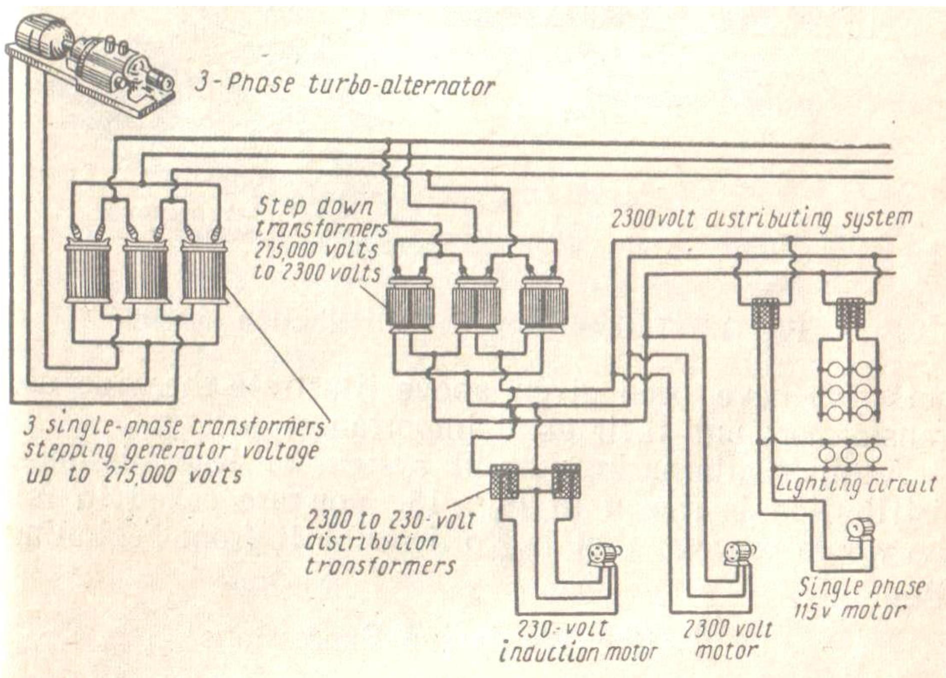

Fig.3. Transmission and distribution system.

III. Translate the following sentences:

(a) 1. The students were asked to carry on the experiment.

2. You will be given two new magazines.

3. I was told to translate the instructions.

4. The questions were answered at once.

(b) 1. The new discovery was much spoken about.

2. This house is lived in.

3. This apparatus is often made use of.

4. The lecture will be followed by a film.

(c) 1. This substance was supposed to have some important properties.

2. This device is assumed to be the best for converting heat into work.

3. The new power plant is known to have been put into operation.

4. This invention was considered to be of great practical importance.

5. A magnetic flux is assumed to consist of magnetic lines of force taken as a whole.

IV. Translate the following sentences:

1. Говорят, что этот прибор описан в предыдущей статье.

2. Считали, что ток течёт от положительного потенциала к отрицательному.

3. Говорят, что мой друг хороший математик.

4. Известно, что Ломоносов основал Московский университет.

5. Кажется, что это вещество имеет некоторые другие свойства.

6. Известно, что переменный ток меняет своё направление.

V. Answer the following questions:

1. What is a transformer?

2. What is a transformer used for?

3. Are there any moving parts in a transformer?

4. Can a transformer be damaged by lightning?
5. What are the principal parts of a transformer?
6. How many windings are there in a transformer?
7. What winding is connected to a load?
8. What is the purpose of a step-up transformer?
9. What is known as a step-down transformer?
10. Does a transformer work on d. c.?
11. In what circuits is the transformer used?
12. For what purpose are step-down transformers used?
13. Is your radio set equipped with a transformer?
14. Can we do, without transformers?
15. Are transformers used both in industry and in our homes?

VI. Form as many words as possible using suffixes and prefixes. Define what parts of speech the new words are and translate them:

engine, apply, differ, electrify, value, opposite, transformer, magnet, conductance.

VII. Form nouns from the following words using suitable suffixes:

construct, develop, consider, distribute, deflect, equip, connect, require, produce, state.

VIII. Arrange the following words and expressions in pairs of synonyms:

1. amount	a. investigation
2. big	b. now
3. matter	c. pipe
4. application	d. quantity
5. at present	e. substance
6. tube	f. to lower

7. research — g. use
8. to step down — h. large

IX. Arrange the following words and expressions in pairs of antonyms:

1. left	a. end
2. increase	b. low
3. beginning	c. long
4. d.c.	d. step-down
5. above	e. in motion
6. step-up	f. less
7. at rest	g. decrease
8. high	h. below
9. short	i. right
10. more	j. a. c

X. Translate the following word combinations:

На основе (чего-либо), по этой причине, само собой разумеется, повышать напряжение, увеличить ток, понижать ток, оказывать сопротивление, электротехника, в целом, в результате, на самом деле.

XI. Translate the following sentences and define the functions of the word but:

1. The Fahrenheit scale is mainly used in English-speaking countries but it is not used in Russia.

2. His scientific activity lasted but twenty years but in these twenty years he did very much.

3. Motors are widely employed not only in industry but also in everyday life.

4. There is but one measuring scale in the instrument.

5. Everyone failed examination in physics but Novikov.

6. A simple transformer is but a kind of induction coil.

XII. Compare:

1. A solenoid and an electromagnet.
2. A direct current and an alternating current.
3. A step-up transformer and a step-down transformer.
4. A stator and a rotor.
5. A primary winding and a secondary winding.

XIII. Translate the following text:

The primary alternating current produces an alternating magnetic flux in the iron core, and this alternating magnetic flux passes through the turns of the secondary winding. According to well-known electro-magnetic laws, this flux produces an alternating e. m. f., or voltage, in the secondary winding. In spite of the fact that there is no electric connection between the two circuits-the primary and the secondary-the application of a voltage to one is known to produce a voltage at the terminal of the other.

Inefficiency in a transformer is caused mainly by heat losses due not only to current flowing in the coils but also to unwanted current induced in the core of the transformer. Currents induced in the core are generally called "eddy currents". The flow of eddy currents is stopped in its progress and the efficiency of the transformer is increased by constructing the transformer core of flat sheets of soft iron.

XIII. Retell the text.

UNIT VIII

ELECTRIC MOTORS

I. Memorize the words to be ready to read and speak about motors.

rotary motion – вращательное движение

an appliance – прибор, приспособление

The motor produces the rotary motion which turns our machinery and various appliances.

commutator – коллектор, переключатель

a brush – щётка

The motor consists of an armature with windings, a commutator and brushes.

starting torque – пусковой момент

A very strong magnetic field is needed to provide a powerful starting torque.

a field coil – катушка обмотки возбуждения

A series field coil is used for providing a strong field necessary for starting.

a shunt field winding – шунтовая обмотка возбуждения

A shunt field winding provides the running conditions.

Small electric motors are used in household appliances.

II. Give the English equivalents of the following words and word combinations:

производить, превращать, вращательное движение, якорь, коллектор, обмотка, щётка, магнитное поле, пусковой момент, последовательная обмотка возбуждения, бытовые приборы, пылесос, стиральная машина.

III. Read and translate the text.

MOTORS

We know the generator to produce electrical energy. To use this generated energy, we need another machine to convert electrical energy into mechanical one. The electric motor is a machine which produces the rotary motion which turns our machinery and various appliances.

The motor consists of an armature with two windings, a commutator and brushes. A very strong magnetic field is necessary to provide a powerful starting torque. It is achieved by adding a series winding to the magnetic field. The series winding is connected in series with the armature. The heavy starting torque passing through the armature winding now passes through the series field coil. This starting torque provides a strong field necessary for starting. The shunt field winding provides the running conditions.

There is a wide variety of d. c. and a. c. motors. Direct-current motors are of three principal kinds and are named according to the manner in which their coils are connected to the armature. They are named series, shunt and compound motors.

Alternating current motors may be single-phase or polyphase ones. They may be divided into two kinds: synchronous and induction motors.

Numerous electric motors are used in industry, transport, mines, farms and even houses. They are the moving elements in various household appliances, such as vacuum cleaners, washing machines, refrigerators and the like. Motors are readily switched on, at will, and they continue running until we switch them off again. Generally speaking, the motor revolutionized industry by making use of energy that can be transmitted from great distances.

IV. Answer the questions to the text using the following introductory phrases: as far as I know; I think quite so; it is really; as far as I remember.

1. What is the motor used for?

2. What parts does the motor consist of?

3. What is necessary to provide a powerful starting torque?

4. How is the series winding connected to the armature?

5. What winding provides the running conditions?

6. What kinds of d. c. motors are there?

7. What kinds of a. c. motors are there?

8. Where are numerous electric motors used?

9. What device revolutionized industry?

V. Agree or disagree using That's not right, That's not true.

Модель: The transformer is used to produce the electrical energy.

- **That's not right**. The generator is used to produce the electrical energy.

1. The generator is used to convert the electrical energy into mechanical one.

2. The motor produces the elliptical motion.

3. The motor consists of an armature with a pair of electromagnets.

4. A very weak magnetic field is needed to provide a powerful starting torque.

5. The series winding is connected in parallel with the armature.

6. Motors are used only in industry.

VI. Agree with the following statements using As far as I know («Насколько мне известно…») и According to the text («Согласно тексту…»)

Модель:- The generator is used for producing electrical energy.

- That's right. **As far as I know** the generator is used for producing electrical energy.

1. The motor is used for converting electrical energy into mechanical one.

2. The motor produces the rotary motion which turns our machinery.

3. A strong magnetic field is provided by adding a series winding to the

magnetic coil.

4. The series winding is connected in series with the armature.

5. The shunt field winding provides the running conditions.

6. There are three kinds of d. c. motors: series, shunt and compound ones.

7. Alternating current motors may be single-phase or polyphase ones.

8. There are two kinds of a. c. motors: synchronous and induction ones.

9. Electric motors are used in industry, transport, farms and even houses.

VII. Translate the sentences.

1. Электрический двигатель используется для превращения электрической энергии в механическую энергию.

2. Двигатель состоит из якоря с двумя обмотками, коллектора и щёток.

3. Мощный пусковой момент обеспечивает сильное возбуждение, необходимое для пуска.

4. Существует большое разнообразие двигателей постоянного и переменного тока.

5. Электрические двигатели используются в бытовых приборах, таких как пылесосы, стиральные машины, холодильники, магнитофоны и тому подобное.

VIII. In the right column find the Russian equivalents of the word combinations.

1. current-carrying conductor	a) двигатель с последующим возбуждением
2. single-loop d. c. motor	b) магнитный поток
3. magnetic field system	c) ток возбуждения (намагничивание)
4. excitation current	d) двигатель с параллельным возбуждением
5. armature current	e) двигатель постоянного тока с одним контуром
6. mechanical output current	f) обратная электродвижущая сила

7. external circuit	g) проводник, несущий ток
8. back e. m. f..	h) механическая выходная мощность
9. shunt wound motor	i) ток якоря
10. series wound motor	j) линейный двигатель
11. compound wound motor	k) редукционная (замедляющая) коробка передач
12. magnetic flux	l) система магнитного поля
13. speed-reduction gearbox	m) двигатель постоянного тока со смешанным возбуждением
14. linear motor	n) внешний контур (цепь)

IX. Read the text "Motor effect" without a dictionary.

MOTOR EFFECT

The motor effect can be regarded as the opposite of the generator effect. In a generator, when a conductor is moved through a magnetic field, a current is induced in the conductor (more correctly, an e. m. f. is induced in the conductor, but the outcome is usually a current in the conductor). In a motor, a current-carrying conductor which is situated in a magnetic field experiences a force which results in the conductor moving (strictly speaking, the force is on the current and not on the conductor, but the current and the conductor are inseparable).

X. Work in pairs. Agree or disagree with the following statements.

1. The motor effect can be regarded as the same as the generator effect.
2. In a generator, when a conductor is moved through a magnetic field, an e. m. f. is induced in the conductor.
3. The motor effect can be regarded as the opposite of the generator effect.
4. In a motor a current-carrying conductor experiences a force which makes the conductor move.

5. A current-carrying conductor is situated in a magnetic field.

6. The current and the conductor are separable.

XI. Read and try to understand the texts given below.

THE D.C. MOTOR PRINCIPLE

In the simple single-loop d. c. motor the magnetic field system is fixed to the frame of the motor, and the rotating part or armature supports the current-carrying conductors. The current in the field coils is known as the excitation current or field current, and the flux which the field system produces reacts with the armature current to produce the useful mechanical output power from the motor armature via carbon brushes and the commutator. It is worthwhile at this point to remind ourselves of the functions of the commutator. First, it provides an electrical connection between the armature winding and the external circuit and, second, it permits reversal of the armature current whilst allowing the armature to continue to produce a torque in one direction.

When the armature winding reaches the horizontal position, the gap in the commutator segments passes under the brushes so that the current in the armature begins to reverse. When the armature has rotated a little further, conductor WX passes under the S-pole and YZ passes under the N-pole. However, the current in these conductors has reversed. In this way it is possible to maintain continuous rotation.

Summary of important facts:

Motor action is caused by the force acting on a current-carrying conductor in a magnetic field. The direction of the force can be predicted by Fleming's left-hand rule.

A d. c. motor consists of a rotating part (the armature) and a fixed part (the frame). Electrical connection to the armature is made via carbon brushes and the commutator. The torque produced by the armature is proportional to the product of the field flux and the armature current. When the armature rotates, a back e. m. f. is induced in the armature conductors (this is by generator action) which oppose the applied voltage.

The four main types of d. c. motor are the separately excited, the shunt wound, the series wound and compound wound machines.

A d. c. machines experience commutation problems; that is, sparking occurs between the brushes and the commutator. These problems can be overcome, in the main, by using brushes which have a finite resistance and which span several commutator segments (wide carbon brushes) together with the use of interpoles or compoles.

D.C. motors larger than about 100 W rating need a starter in order to limit the current drawn by the motor under starting conditions to a safe value.

PRINCIPLE OF THE A. C. MOTOR

Imagine that you are looking at the end of the conductor when the S-pole of a permanent magnet is suddenly moved from left to right across the conductor. By applying Fleming's right-hand rule, you can determine the direction of the induced e. m. f. and current in the conductor. You need to be careful when applying Fleming's rule in this case, because the rule assumes that the conductor moves relatively to the magnetic flux (in this case it is the flux that moves relatively to the conductor, so the direction of the induced e. m. f. is determined by saying that the flux is stationary and that the conductor effectively moves to the right). You will find that the induced current flows away from you.

You now have a current-carrying conductor situated in a magnetic field. There is therefore force acting on the conductor, and you can determine the direction of the force by applying Fleming's left hand rule. Application of this rule shows that there is force acting on the conductor in the direction of movement of the magnetic field.

That is, the conductor is accelerated in the direction of the moving magnetic field.

This is the basic principle of the a. c. motor. An a. c. motor therefore provides a means for producing a "moving" or "rotating" magnetic field which cuts conductors on the rotor or rotating part of the motor. The rotor conductors have a current induced in them by the rotating field, and are subjected to a force which causes the rotor to rotate in the direction of movement of the magnetic field.

XII. Using your key words describe the basis of a d. c. motor.

XIII. Work in pairs.

Ask each other questions on the text "Principles of the A.C. motor". Answering the questions, use introductory phrases: certainly; to my mind; if I am not mistaken; as far as I know.

XIV. Read and try to understand the text without a dictionary.

ROTATING AND "LINEAR" A. C. MOTORS

Most electrical motors have a cylindrical rotor, that is, the rotor rotates around the axis of the motor shaft. This type of motor generally runs at high speed and drives its load through a speed-reduction gearbox. Applications of this type of motor include electric clocks, machines in factories, electric traction drives, steel rolling mills, etc.

Another type of motor known as a linear motor produces motion in a straight line (known as rectilinear motion); in this case the mechanical output from the motor is a linear movement rather than a rotary movement. An application of this type of motor is found in railway trains. If you imagine the train to be "sitting" above a single metal track (which is equivalent to the "conductor") and the "moving magnetic field" is produced by an electromagnetic system in the train then, when the "magnet" is made to "move" by electrical means, it causes the system to produce a mechanical force between the electromagnet and the track. Since the track is fixed to the ground, the train is "pulled" along the conductor.

XV. Make up dialogues on the following situations:

a) types of motors and their application;

b) advantages and disadvantages of a. c. and d. c. motors.

SUPPLEMENTARY TEXTS

COMPUTER PROGRAMMING LANGUAGES

The CPU of a computer – whether in a microcomputer or the largest mainframe – is programmed in binary code. It is almost impossible for humans to use binary code for programming. The nearest usable language to the binary code that the CPU needs is Assembly Language. Assembly Language instructions have a one-for-one correspondence to machine instructions: in other words, each Assembly Language instruction has an exact equivalent in binary code.

Assembly Language is not easy to learn, and it takes a long time to program a computer to do anything useful. An Assembly Language program to input two six-digit decimal numbers and divide one into the other, expressing the result as a decimal number, would take an experienced Assembly Language programmer a full week to write. Clearly there needs to be an easier way.

Assembly Language is known as a low-level language because it is close to machine language. Other computer languages are much nearer to English, and are consequently easier to learn. Such languages can make it much simpler to program a computer, and are used wherever possible. Such computer languages are called high-level languages.

Programming languages are called “low level” when they are dose to machine language and don’t look like English. They are called “high level” when they are nearer to English.

There are two classes of high-level language: compiled languages and interpreted languages. Both translate something closer to English into a code understood by the CPU, but they do it in different ways. We will start by looking at the most widely used computer language of all, BASIC. The name is an acronym for Beginners All-purpose Symbolic Instruction Code, and it was first used in the USA for teaching programming to university students, but has since been developed and extended until it can be used for a wide range of programming applications. BASIC is an interpreted language. A long and complex program (written in Assembly Language!) is kept in the ROM or RAM – this program is the BASIC Interpreter, and translates a program written in BASIC language into the binary code that CPU requires. One of the most popular compiled languages is still Pascal. The name is not an acronym this time, but is a tribute to Blaise Pascal, a seventeenth-century mathematician and philosopher. Pascal was designed at the outset to be a compiled language, and also to have a form such that its users are almost forced to write programs in an orderly, understandable way. Pascal compilers do not actually compile directly to machine code. Instead, they compile into an intermediate form called a P-code; the P-code is itself then run as an interpreted "language", using a P-code interpreter! However, the "interpreter" is generally called a translator in this context, and the result is something that runs a lot faster than an interpreted language, because all the hard part of the translation (Pascal to P-code) is done before running the program.

The speed of a compiled language is a function of the quality of the compiler – all else being equal, the better the compiler, the faster the object code will run. The skill in writing a compiler is in getting it to produce a relatively economic code. There are, of course, many different high-level programming languages. They are easier to write than Assembly Language, and they all run more slowly, for no compiler or interpreter has yet been written that can equal well-written Assembly Language for efficiency. Programming computers is something people can still do better than computers!

One of the oldest programming languages (and still going strong!) is FORTRAN (FORmula TRANslator). It is an excellent language for science and mathematics, and bears a close similarity to BASIC, which was developed from it.

Another language that is still widely used is COBOL (Common Business Oriented Language) which is good for producing lots of long reports, inventory and stock control, but too "wordy" for scientific work, graphic programs or mathematics. Pascal itself is a good general-purpose language, but is not particularly good for control applications. For heavy-weight applications – defence networks, for example – languages like FORTH and Ada are used. For experiments in artificial intelligence (trying to make a computer behave like a person) a language called LISP is often used.

For applications programming where transportability (jargon for ease of translation for different makes of microprocessor and computer) is important, the programming language C, and its newer variants C+ and C++, are supreme. C++ is the language of choice for most commercial and scientific applications, because it is sufficiently low level to provide a very good speed of execution, it puts detailed control of the machine into the programmer's hands, and it is transportable.

LOVE AT FIRST BYTE

From opposite ends of the U.S., they carried on the computer industry's fiercest rivalry. Based outside New York City, International Business Machines has long looked down on Apple Computer, dismissing it as a ragtag bunch of rabble-rousers. Far away in California's Silicon Valley, Apple (1990 revenues: $5.6 billion) attacked IBM ($69 billion) as an impersonal bureaucracy, mocking the company in TV ads as Big Brother and depicting its customers as lemmings. The warring companies forced computer users to choose sides, sometimes dividing family members against one another. Those wanting easy-to-use software favored Apple, while others threw their lot behind IBM because its PCs were backed by a wider assortment of programs.

But in a rapidly changing industry, IBM and Apple have found much in common lately. After years of dominating their own spheres of influence, they now face similar woes: declining market share, relentless low-cost competitors and rapidly aging technology. While IBM and Apple remain the biggest players, with a combined market share of 38%, their rivalry has lost its potency, as brand loyalty has given way to price competition. Today IBM and Apple are more like a pair of aging prizefighters whose bout gets second billing.

The two companies decided last week to put away their boxing gloves. IBM and Apple plan to join forces and share technology in a potentially powerful partnership that could reshape the computer industry. The culmination of week of negotiations, the collaboration could help plug large gaps in their product lines and position both companies for the future. Among the elements:

- The two companies will form a joint venture to develop an advanced operating system, the basic controlling software of computers, which IBM and Apple will use in their machines and sell to other companies.

- Apple's user-friendly Macintosh system will be integrated into IBM's product line, including the large computers that serve as the heart of corporate systems.

- Apple will gain access to IBM's advanced, high-speed microprocessors, which will be incorporated into future editions of the Macintosh and other machines.

- The two computer makers will seek to develop a new generation of high-powered, multimedia hardware and software, which could be marketed under both brand names.

The deal represents a major realignment in the PC industry. "Who would have thought these two companies could possibly see eye to eye on anything? It's like a surfer girl marrying a banker," declared Richard Shaner, publisher of Computer-Letter. If the venture is successful, adds Shaffer, "it could create the most fearsome force in computing ever." Machines made by the two companies could become virtual look-alikes, which would not only eliminate the need for consumers to choose sides but also end much of the confusion prevalent in the industry over the lack of standards.

None of this would have been thinkable a decade ago. Apple founders Steven Jobs and Stephen Wozniak were riding high on the widespread acceptance of their best seller, the Apple He, when IBM launched its PC in

1981. While it was bulky, expensive ($2,600, vs. $1,395 for the Apple machine) and difficult to use, the PC was quickly adopted as the industry standard because IBM had a lock on the Big Business market. Apple eventually sold nearly 3 million of it s He's, mainly for school and home use, but the company was largely shunned by corporations.

When Apple unveiled the revolutionary Macintosh in 1984, the rivalry with IBM reached full boil. Taking on Big Blue had become an obsession for the Silicon Valley boys, who called themselves "Blue-busters." Jobs launched Macintosh with an evangelistic zeal, exhorting an auditorium packed with dealers, customers and employees, "IBM wants it all end is aiming its guns on its last obstacle to industry control, Apple. Will Big Blue dominate the entire computer industry...? Was George Orwell right?" As the frenzied crowd shouted a chorus of "No!," Jobs cued a now notorious TV commercial known as "1984,"which was to run only once, during the Super Bowl football game.

The ad showed workers staring zombie-like at a Big Brother on a viewing screen, which a heroic female athlete smashed with a sledgehammer.

Offering stunning graphics and a stylish design, the Macintosh caught on well in the home and school markets, where Apple's machines now outsell IBM's by a two-to-one margin. Big Blue has always been frustrated in those markets. In the mid-80s, IBM offered the PCjr, a stripped-down version of its best seller, but the machine flopped because it couldn't operate many of the heavy-duty software programs designed for the PC. Yet IBM has virtually locked Apple out of the office market, mainly because IBM's operating software has been adopted for 90% of the PCs now in operation. Apple has never been able to match its rival's marketing clout either. The California Company's sales force is about a tenth the size of IBM's.

Lately, changes in industry taste have reduced the relevance of the IBM-Apple rivalry. Rather than choose sides, customers now insist that computers work together in networks, regardless of the make or model. That has harmed Apple, since its operating software is not the most compatible. But it has been no blessing for IBM either, because its operating system is so common that customers often prefer to buy clone machines that work like IBM's but cost less. Customers have become more concerned about price than brand names or even high performance. That has turned things upside down for IBM and Apple, which find themselves struggling to make their products less distinctive and more compatible with their other rivals. Apple has developed desktop computers that not only run its Macintosh software system but also use the same disk operating system or DOS used by IBM models. And Big Blue has countered with desktop computers that are more user friendly, in the spirit of Macintosh.

Yet neither IBM nor Apple has been able to halt customer defections. IBM's market share in PCs has dropped by half, to 23%, while Apple's has declined to 15%, from 18%. The changing marketplace has forced both companies to make some painful adjustments. In the largest layoff in the company's history, Apple will now pare 1,500jobs from its payroll, a reduction of about 10%. The company is expected to post an earnings decline for the past quarter, largely because of price cutting. IBM, which during the January-March period reported the first quarterly loss in its 80-year history, plans to reduce its labor force by some 14,000 workers this year, a 4% cut.

Another problem that drove IBM and Apple into each other's arms is their growing friction with some powerful partners, most notably Microsoft, the software giant outside Seattle, which is ran by wunder-kind billionaire William Gates III. Microsoft was the creator of MS-DOS, the software that runs the IBM PC, but the two companies have had a falling out over the next generation, called OS/2, which runs IBM's line of PS/2 computers. Microsoft developed OS/2as well, but IBM believes the software company has undermined sales of that software by pushing a highly successful program called Windows 3.0, which enables old MS-DOS software to work much like a Macintosh. That has also alienated Apple, which contends that Microsoft stole elements of Windows from Macintosh programs. The new IBM-Apple venture, which will develop its own software, could spell the end of OS/2 and any remaining relationship with

Microsoft. “We’re flabbergasted,” say Steven Ballmer, Microsoft’s senior vice president. “This does not bode well for future cooperation between IBM and Microsoft.”

The new alliance scorns another powerful company, Intel, which has supplied the microprocessors for IBM’s machines and has commanded an almost monopoly position as a maker of IBM-compatible chips. Possibly to foster more competition, the new partnership says it will buy advanced processors from Illinois-based Motorola, whose chip business has been suffering lately because some of its big customers, including Unisys have been in decline. IBM has been busy lining up other partnerships as well. Only a day after announcing its deal with Apple, IBM said it would join forces with Germany’s Siemens A.G.to produce a powerful new 16-mega-bit memory chip, which will hold four times as much data as current models. The collaboration could give IBM-Siemens a leg up in the race against Japanese companies to bring the new chip to market.

The IBM-Apple combination has its risks. Most PC joint ventures have foundered, and this one will have to stand the test of vastly differing corporate cultures. Consumers could be disillusioned with both companies at first, viewing Apple as selling out and IBM as consorting with free spirits from the West Coast. But if the collaboration works as well in practice as it is planned on paper, the biggest winners will be the customers. Consumers will no longer have to worry about divided loyalties and incompatible programs. They won’t be in Apple’s orbit or IBM’s, but in the best of both computer worlds.

MICHAEL FARADAY

Michael Faraday (1791–1867), one of the greatest men of science, had little chance to get an education. His father was a blacksmith who made his living in the heat of his forge, and Faraday was born to work with his hands, too.

Being thirteen years of age, he went as apprentice to learn book-binding. He read many of the books he had to bind and made clear and careful notes from those books that interested him most. Once when binding an encyclopedia, he ran across an article on electricity. When Faraday turned to that page and began to read he knew nothing of the subject, but it struck his imagination and aroused his interest. With the little money he could save, he bought a cheap and simple apparatus and set to make experiments. The farther he went along the road, the more interested lie became.

He attended the lectures of Humphry Davy, an outstanding scientist and the most popular lecturer in London at that time. It was Davy who helped Faraday to become an assistant at the laboratory of the Royal Institute and to get a profounder knowledge of the subject.

While still an assistant he helped Davy to create a safety lamp for miners. He learned chemistry, lectured to young people interested in science and wrote for a quarterly scientific journal.

In his spare moments Faraday was working on the problem of turning gases, into liquids. We know him to have heated hydrate of chlorine in a sealed tube and thus to have succeeded in liquefying chlorine. An important discovery of Faraday was that of benzol which he separated from condensed oil gas, and which since then found world-wide application.

For several years he is known to have been working at the problem of a perfect optical glass and to Lave made a glass that greatly improved the telescope.

Yet the problem of electricity and magnetism interested him above all. All scientific worlds had known by that time that if a current is run through a copper wire wound around a piece of iron, the iron becomes a magnet. If electricity magnetizes, why won’t magnetism electrify? That was the question Faraday asked himself over and over. For a long time he tried different experiments to solve the problem. At last in 1831 he made his major discovery in the field of electricity – the electromagnetic induction.

But Faraday's work on electricity could not end at this point. He set about testing electricity from every known source and after a series of tests came to the conclusion that electricity, whatever the source may be, is identical in its nature.

Among a number of other discoveries he is also known to have measured for the first time the electric current, and to have made several important observations on the conductivity of different materials. Although Faraday enjoyed world-wide popularity he remained a modest man never wanting either to accept high titles or to get any money out of his numerous discoveries.

He was one of those great men who made possible the age of electricity in which we live, all the marvels it brings us and all those it may bring to the future generations.

THE DISCOVERY OF ELECTO-MAGNETIC INDUCTION

It is at this important juncture in the history of electrical research 49 that we see the first, shy attempts to make the force of Nature do some work. Now we are concerned with the development of electricity for the transmission of energy.

One day in 1819 a Danish physicist Hans Christian Oersted, was lecturing at the University of Kiel, which was then a Danish town. Demonstrating a galvanic battery, he held up a wire leading from it when it suddenly slipped out of his hand and fell on the table across a marine's compass that happened to be there. As he picked up the wire again he noticed to his astonishment that the needle of the compass no longer pointed north, but had swung completely out of position. He switched the current off, and the needle pointed north again.

For a few months he thought over this incident, and eventually wrote a short report on it. No one could have been more surprised than Oersted at the extraordinary impact which his discovery made on Physicists all over Europe and America. At last the long sought connection between electricity and magnetism had been found! Yet neither Oersted nor his colleagues could for see the importance of this phenomenon, for it is the connection between electricity, and magnetism on which the entire, practical use of electricity in our time is founded!

What was it that Oersted had discovered? Nothing more than that an electrically charged conductor, such as the wire, leading from a battery, is the centre of a magnetic “field”, and this has the effect of turning a magnetic needle at a right angle with the direction in which the current is flowing; not quite at a right angle, though, because the magnetism of the earth also influences the needle. Now the physicists had a reliable means of measuring the strength of a weak electric current flowing through a conductor; the galvanoscope, or galvanometer, such a simple instrument consisting of a few wire loops and a magnetic needle whose deflection indicates the strength of the current.

Prompted by the research work of Andre-Marie Ampere, the great French physicist whose name has become a household word as the unit of the electric current, the Englishman Sturgeon experimented with ordinary, non-magnetized iron. He found that any piece of soft iron could be turned into a temporary magnet by putting it in the centre of a coil of insulated wire and making an electric current flow through the coil. As soon and as long as the current was turned on the iron was magnetic, but it ceased to be a magnet when there was no 50 more current. Sturgeon built the first large electro-magnet, and with this achievement there began the development of the electrical telegraph and later the telephone.

But there was yet another, and perhaps even more important, development which began with the electro-magnet. Michael Faraday repeated the experiments of Oersted, Sturgeon, and Ampere. His brilliant mind conceived this idea: if electricity could produce magnetism, perhaps magnetism could produce electricity!

But how? For a long time he searched in vain for an answer. Every time he went for a walk in one of London’s parks he carried a little coil and a piece of iron in his pocket, taking them out now and then to look at them. It was on such a walk that he found the solution. Suddenly, one day in 1830, in the midst of

Green Park (so the story goes), he knew it: the way to produce electricity by magnetism was to produce it by motion.

He hurried to his laboratory and put his theory to the test. It was correct. A stationary magnet does not produce electricity. But when a magnet is pushed into a wire coil current begins to flow in the coil; when the magnet is pulled out again, the current flows in the opposite direction. This phenomenon, confirms the basic fact that the electric current cannot be produced out of nothing – some work must be done to produce it. Electricity is only a form of energy; it is not a "prime mover" in itself.

What Faraday had discovered was the technique of electromagnetic induction, on which the whole edifice of electrical engineering rests. He soon found that there were various ways of transforming motion into electric current. Instead of moving the magnet in and out of the wire coil you can move the coil towards and away from the magnet; or you can generate electricity by changing the strength of stationary magnet; or you can produce a current in one of two coils by moving them towards and away from each other while a current is flowing in the second.

Faraday then substituted a magnet for the second coil and observed the same effect. Using two coils wound on separate sections of a dosed iron ring, with one coil connected to a galvanometer and the other to a battery, he noticed that when the circuit of the second coil was closed the galvanometer needle pointed first in one direction and then returned to its zero position. When he interrupted the battery circuit, the galvanometer jerked into the opposite direction. Eventually, he made a 12-inch-wide copper disc which he rotated between the poles of strong horse-shoe magnet: the electric current which was generated in the copper disc could be obtained from springs or wire brushes touching the edge and axis of the disc.

Thus Faraday demonstrated quite a number of ways which motion could be translated into electricity. His fellow-scientists at the Royal Institution and in other countries were amazed and impressed – yet neither he nor they proceeded to make practical use of his discoveries, and nearly forty years went by before the first electric generator, or dynamo, was built.

Meanwhile, fundamental research into the manifold problems of electricity continued. In America, Joseph Henry, professor of mathematics and natural science, also starting from Oersted's and Sturgeon's observations, used the action of the electric current upon a magnet to build the first primitive electric motor in 1829. At about the same time, George Simon Ohm, a German school-teacher found the important law of electric resistance: that the amount of current in a wire circuit decreases with the length of the wire, which acts as resistance. Ohm's excellent research work remained almost unnoticed during his lifetime, and he died before his name was accepted as that of the unit of electrical resistance.

EDISON' LIGHTING SYSTEM

It was only in the last quarter of the nineteenth century that electricity began to play its part in modern civilization, and the man who achieved more in this field of practical engineering than any of his contemporaries was the American inventor, Thomas Alva Edison. His dramatic career is too well known, and has been described too often, to be told again; it may suffice to recall that he became interested in the problem of electric lighting in 1877, and began to tackle it with the systematic energy which distinguished him from so many other inventors of his time. Edison was no scientist and never bothered much about theories and fundamental laws of Nature; he was a technician pure and simple, and a very good business man as well.

He knew what had been done in the field of electric lighting before his time, and he had seen some appliances of his contemporaries, such as the arc-lamp illuminations which had been installed here and there. Two sticks of carbon, nearly touching, can be made to produce an electric arc which closes the circuit. Many scientists and inventors who tried to tackle the problem were therefore convinced that only incandescent electric light – produced by some substance glowing in a vacuum so that it cannot burn up – could ever replace gas lighting, then the universal system of illumination in Europe and America.

Edison put his entire laboratories at Menlo Park to the task of developing such a lamp. The most important question was that of a suitable material for the filament. He experimented with wires of various metals, bamboo fiber, human hair, paper; everything was carbonized and tried out in glass bulbs from which the air had been exhausted. In the end – it is said that a button hanging thread on his jacket gave him the idea – he found that ordinary sewing thread, carefully carbonized and inserted in the airless bulb, was the most suitable material. His first experimental lamp of 1879 shed, its soft, yellowish light for forty hours: the incandescent electric lamp was born.

It was, no doubt, one of the greatest achievements in the history of modern invention. Yet Edison was a practical man who knew well that the introduction of this revolutionary system of illumination must be properly prepared. He worked out methods for mass-producing electric bulbs at low cost, and devised circuits for feeding any number of bulbs with current. He found that 110/220 volts was the most suitable potential difference and would reduce transmission losses of current to a minimum – he could not have foreseen that the introduction of that voltage was to set the standard for n century of electric lighting. But most important of all "accessories" of the lamp was the generator that could produce the necessary high-tension current.

Since Faraday's ingenious discovery of the way in which movement could be transformed into electricity, only a small number of engineers had tried to build generators based on this principle. But none of these generators answered the particular requirements of Edison's electric light: so he had to design his own generator, which he did so well that his system – apart from minor improvements and of course the size of the machines – is still in general use today.

It is little known that the first application of Edison's lighting system was on board an arctic-expedition steamer, the "Jeanette", which the inventor himself equipped with lamps and a generator only a few weeks after his first lamp had lit up at Menlo Park. The installation worked quite satisfactorily until the ship was crushed in, the polar ice two years later.

Edison, a superb showman as well as a brilliant inventor, introduced his electric lamp to the world by illuminating his own laboratories at Menlo Park with 500 bulbs in 1880. It caused a sensation. From dusk to midnight, visitors trooped around the laboratories, which Edison had thrown open for the purpose, regarding the softly glowing lamps with boundless admiration. Extra trains were run from New York, and engineers crossed the Atlantic from Europe to see the new marvel. There was much talk about the end of gas-lighting, and gas shares slumped on the stock exchanges of the world. But a famous Berlin engineer – none other than Werner von Siemens, who later became Edison's great rival in central Europe – pronounced that electric light would never take the place of gas. When Edison showed his lamps for the first time in Europe, at the Paris Exhibition of 1881, a well-known French industrialist said that this would also be the last time.

Meanwhile, however, Edison staked his money and reputation on a large-scale installation in the middle of New York. He bought a site on Pearl Street, moved into it with a small army of technicians, and built six large direct-current generators, altogether of 900 h. p., powered by steam-engines. Several miles of streets were dug up for the electric cables – also designed and manufactured by Edison – to be laid, and eighty-five buildings were wired for illumination. On 4 September 1881 New Yorkers had their first glimpse of the electric age when 2,300 incandescent lamps began to glow at the throwing of a switch in the Pearl Street power station. Electric lighting had come to stay. And what was most important: Edison had finally established a practical method of supplying electricity to the homes of the people.

Pearl Street was not the first generator station to be built. A 1 h. p. generator for the supply of current for Edison lamps was built in 1881. In Germany, Werner von Siemens did more than any other engineer for the introduction of electric lighting, in which he had first refused to believe, by perfecting his “dynamo”, as he called the generator for continuous current.

Spectacular as the advent of electric lighting was, it represented only one aspect of the use of electricity, which was rapidly gaining in popularity among industrial engineers. For a century, the reciprocating steam-engine had been the only important man-made source of mechanical energy. Bui its power was limited to the place where it operated; there was no way of transmitting that power to some other place where it might have been required. For the first time, there was now an efficient means of distributing energy for lighting up homes and factories, and for supplying engines with power.

The engine which could convert electric energy into mechanical power was already in existence. As early as 1822, nearly a decade before he found the principle of the electric generator, Faraday outlined the way in which an electric motor could work: by placing a coil, or armature, between the poles of an electromagnet; when a current is made to flow through the coil the electro-magnetic force causes it to rotate – the reverse principle, in fact, of the generator.

The Russian physicist, Jacobi built several electric motors during the middle decades of the 19th century.

Jacobi even succeeded in running a small, battery-powered electric boat on the Neva River in St. Petersburg. All of them, however, came to the conclusion that the electric motor was a rather uneconomical machine so long as galvanic batteries were the only source of electricity. It didn’t occur to him that motors and generators could be made interchangeable.

In 1888, Professor Galileo Ferraris in Turin and Nikola Tesla – the pioneer of high-frequency engineering – in America invented independently and without knowing of each other’s work, the induction motor. This machine, a most important but little recognized technical achievement, provides no less than two-thirds of all the motive power for the factories of the world, and much of modern industry could not do without it. Known under the name of “squirrel-cage motor" – because it resembles the wire cage in which tame squirrels used to be kept – it has two robust circular rings made of copper or aluminum joined by a few dozen parallel bars of the same material, thus forming a cylindrical cage. It is built into an iron cylinder which is mounted on the shaft, and forms the rotor, the rotating part of the is exposed to a rotating magnetic field set up by the stator, the fixed part of the machine, consisting of many interconnected electrical conductors called the winding. The relative motion between the magnetic field and the rotor induces voltages and currents which exert the driving force, turning the "cage" round.

Although the induction motor has been improved a great deal and its power increased many times over since its invention, there has never been any change of the underlying principle. One of its drawbacks was that its speed was constant and unchangeable. Only in 1959 did a research team at the University of Bristol succeed in developing a squirrel-cage motor with two speeds – the most far reaching innovation since the invention of the inductor motor. The speed-change is achieved by modulating the pole-amplitude of the machine.

From the day when Edison's lamps began to glow in New York, the entire world asked for electricity. Already a year earlier, Werner von Siemens had succeeded in coupling a steam-engine directly to a dynamo. But the engineers had their eves on another, cheaper source of mechanical power than the reciprocating steam-engine: that of falling water. We do not know which of them suggested the idea of a hydroelectric power station for the first time; it was probably very much "in the air". Back in 1827, a young Frenchman had won the first prize ill a competition for the most effective water turbine in which the water would act on the wheel inside a casing instead of from outside. It was one of the prototypes of the modern water turbine. In the 1880's, an American engineer designed a turbine wheel with enormous bucket-shaped blades along the rim, and a few American towns with waterfalls installed these turbines coupled to Edison generators. This type proved especially efficient where the fall of water was sleep but its quantity limited; for a low fall of water the turbine

– with only four large blades proved better suited. However, the type which appeals most to the engineers is now the turbine for falls of water from 100 to 1000 feet, with a great number of curved blades.

The power-station which convincingly showed the enormous possibilities of hydro-generated electricity was the one at Niagara Falls, begun in 1891, and put into operation a few years later with an output of 5000 h. p. – it is 8 million h. p. today. The early power stations generated direct current at low voltage but they could distribute it only within a radius of a few hundred yards. The Niagara station was one of the first to use alternating current (although the skeptics prophesied that this would never work), generated a high voltage; this was transmitted by overhead cables to the communities where it was to be used, and here "stepped down" into lower voltages (110 or 220) for domestic and industrial use by means of transformers. High voltage transmission is much more economical than low-voltage; all other circumstances being equal, if the transmission voltage is increased tenfold the losses in electric energy during transmission arc reduced to one-hundredth. This means that alternating current at tens or even hundreds of thousands of volts, as it is transmitted today, can be sent over long distances without much loss.

These ideas must have had something frightening to the people at the end of the last century, when electricity was still a mysterious and alarming novelty. The engineers who built London's first power station, with a 10000-volt generator, in 1889, and their German colleagues who set up a 16000-volt dynamo driven by a waterfall in the River Neckar, to supply Frankfurt, 100 miles away, with electricity in 1891 – these men must have felt like true pioneers, derided, despised, and abused by the diehards. There were, of course, also some powerful commercial interests involved, for the gas industry feared for its monopoly in the realm of lighting – and with a good deal of justification as it turned out.

THE DEVELOPMENT OF ILLUMINATION

Perhaps we might in this connection give a brief sketch of the development of illumination. From his earliest times, Man has had an intense dislike of the dark. Besides, as soon as he had learnt how to use his brain the long winter nights with their enforced idleness must have bored him. Lightning, the fire from heaven, gave him the first "lamp" in the shape of a burning tree or bush. He prolonged the burning time of firewood by dipping it into animal fat, resin or pitch: thus the torch was invented. It was in use until well into the nineteenth century; many old town houses in England still have torch-holders outside their front doors, where the footmen put their torches as their masters and mistresses stepped out of the carriages.

Rough earthenware, oil lamps were in use in the earliest civilizations; these lamps, though much refined, were still quite common a hundred years ago. The Romans are usually credited with the invention of the candle, originally a length of twisted flax dipped in hot tallow or beeswax which later hardened as it cooled off. Candles were at first expensive, and only the rich and the church could afford them. As late as the 1820's steam candles – cheap and mass manufactured came into use, and still later they began to be made of paraffin wax.

By that time, however, a new kind of illumination had been introduced until all over the civilized countries: gaslight. In the l690's an English scientist Dr. John Clayton observed that the gases which developed in coal-pits and endangered the lives of the miners were combustible. He experimented with pieces of coal, which he "roasted" over a fire without allowing them to burn up, and found that the resulting gas gave a pleasant, bright flame. German and French chemists repeated his experiments, but a hundred years passed alter his discovery before gas became a practical form of illumination.

William Murdock, a Scotsman who started his career as a mechanic, took up Clayton's idea. He built an iron cauldron in his cottage garden and healed coal in it. This incomplete combustion produced a mixture of highly inflammable carbon monoxide and nitrogen. He piped the gas into his house and fixed taps in every room. Many a night the people of Redruth stood in silent awe around Murdock's cottage, gazing at the wonderful new lamps which shed a bright light throughout the house.

After two years of experimenting, he persuaded his employer, Watt, to let him illuminate the Soho factory by gaslight. The installation was completed just in time to celebrate the peace treaty of Amiens and the end of the Anglo-French war in 1802 with the first public exhibition of gas lighting in and around the factory.

A year later, gaslight came to London. The people of the capital saw for the first time a street bathed in light at night. But many people were against it.

"London is now to be lit during the winter months with the same coal-smoke that turns our winter days into nights," – complained Sir Walter Scott, and even such an eminent man as Sir Humphry Davy exclaimed Mint he would never acquiesce in a plan to turn St. Paul's into a gasometer.

But the progress of gas lighting could not be stopped; the main argument for it was that it would increase public safety in the streets it took much longer to persuade the people that there was no danger to their homes if they had gas tubes laid into them.

The introduction of gaslight in the factories had an especially far-reaching effect it made the general adoption of night shifts possible. The first industry to do this was the Lancashire, textile industry, for the workers at their rooms were now able to watch the threads at any time of the day or night.

Murdock's assistant was responsible for many improvements; among other things he invented the gas meter, and put up gas lamps on Westminster Bridge in 1813. Three years later, most of London's West End was already gaslit, and by 1820 nearly all Paris. New York followed in 1823. In Germany there were many objections to be over-come until the advantages of gaslight were recognized.

William Murdock lived long enough to witness the beginning of another development whose importance few people recognized at the time: gas cooking. In 1839 the first gas-oven was installed at a hotel, and a dinner cooked for a hundred guests. For a long time, however, this idea did not catch on. But when towards the end of the century the electric light began to take over from the gas lamp, the industry was forced to make a new effort so as not to be squeezed out of existence. In 1885 the Austrian physicist Carl Auer introduced his incandescent gas mantle, which quickly superseded the open (and dangerous) gas flames which had until then been in use. He used the same principle as Edison in his electric lamp; his gas-mantle was a little hood of tulle impregnated with thorium or cerium oxide. For a while, incandescent gaslight gained ground, and many people who had already installed electric cables had them torn up again. But in the end electricity won because it was more effective and more economical.

Only then did gas cooking emerge as a new aid to the world’s housewives. It has still its place in the kitchen; gas-operated refrigerators, gas stoves, and central-heating systems arc more recent developments. Gas has by no means outstayed its welcome in our civilization.

Auer himself was responsible for one of the decisive improvements in the electric bulb, the great rival of his gas lamp. Using his experience with rare earths he developed a more efficient filament than Edison’s carbonized thread-osmium. It was superseded in its turn by the tungsten “wolfram” filament, invented by two Viennes scientists in the early 1900s. Since about 1918, electric bulbs have been filled with gas; today, a mixture of argon and nitrogen is in general use. Is the incandescent lamp now also on its way out? In innumerable offices, factories, public buildings and vehicles, and a good many homes (especially in the kitchens) the fluorescent lamp has taken over from it. This is based on two scientific phenomena that have long been known: that certain materials can be excited to fluorescence by ultraviolet radiation, and that an electric discharge through mercury under low pressure produces a great deal of invisible ultraviolet radiation. Professor Becquerel, grandfather of the scientist whose work on uranium rays preceded the discovery of radium, attempted to construct fluorescent lamps as long ago as 1859 by using a discharge tube. American, German and other French physicists worked on the same lines, and eventually the new type of lamp found its first applications for advertising (neon light). The difficulty was the production of a daylight-type of light with sufficient blue in its spectrum.

The modern fluorescent lamp consists of a long, gas-filled glass tube, coated inside with some fluorescent powder; this lights up when excited by the invisible ultraviolet rays of an arc passing from the electrode at one end to that at the other. Strip lighting is extremely efficient and needs little current because it works "cold" i.e. very little electrical energy is turned into waste heat as in incandescent lamps. It is roughly fifty times more effective than Edison's first carbon-filament lamps.

The mercury or sodium vapour lamps which arc now used on the roads arc "discharge" lamps, invented in the early 1930s. They have a "conductor" in the form of gas or metallic vapour at low pressure; this is raised to incandescence by the electric current, and emits light of one characteristic colour, greenish-blue (mercury vapour) or yellow (sodium vapour). They are "monochrome" lamps, that is, they emit light of only one colour, which makes it easier for the motorist to distinguish objects on the roads; it is also less scattered by mist or fog. True, that light makes people look like ogres – but it makes our streets definitely safer by night.

THE STEAM TURBINE

It is most important to remember that electricity is only a means of distributing energy, of carrying it from the place where it is produced to the places where it is used. It is not a "prime mover" like the steam-engine or even the water mill. A generator is no use at all unless it is rotated by a prime mover. During the first few years of electric power there was no other way of moving the generators than either by the force of falling water or by ordinary steam-engines.

Soon, however, there came a new and very efficient prime mover, the steam-turbine. The steam-turbine must be a much more efficient and powerful prime mover than the reciprocating engine because it must short-cut the complicated process of converting steam energy into rotary motion via reciprocating motion. But the problems involved in building such a machine seemed formidable, especially hint of high-precision engineering. It was only towards the end of the nineteenth century that engineering methods were developed highly enough for a successful attempt.

Two men undertook it almost simultaneously. The Swedish engineer, Gustaf Patrik de Laval, built his first model in 1883. He made the steam from the boiler emerge from four stationary nozzles arranged around the rim of a wheel with a great number of small inches, de Laval's turbine wheel rotated at up to 10000 revolutions per minute. He supported the wheel on a flexible shaft so that it would adjust itself to the fluctuation of procure – which at Midi speeds, would have broken a rigid shaft in no time.

De Laval geared an electric generator to his turbine alter he had succeeded in reducing the speed of rotation to 300 r.p.m. His turbo generator worked, but its capacity was limited, and it was found unsuitable for large-scale power stations. Although the simplest form of a machine has often proved the most efficient one in the history of technology, this was not the ease with the team-turbine. Another inventor, and another system, proved much more successful.

In 1876 Charles Parsons began to work on the idea of a steam-turbine, for which he foresaw a wide range of applications. The reciprocating steam-engine, which was unable to convert more than 12 per cent of the latent energy of coal into mechanical power, was not nearly efficient enough for the economical generation of electricity – energy leaked out right and left from the cylinder, and the condenser. Besides, there were limits to the size in which it could be built, and therefore to the output: and Parsons saw that the time had come to build giant electric power stations.

As he studied the problem he understood that the point where most would-be turbine inventors had been stumped was the excessive velocity of steam. Even steam at a comparatively low pressure escaping into the atmosphere may easily travel at speeds of more than twice the velocity of sound – and high-pressure steam may travel twice as fast again, at about 5000 feet per second. Unless the wheel of a turbine could be made to rotate at least at half the speed of the steam acting upon its blades, there could be no efficient use of its energy. But the centrifugal force alone, to say nothing of the other forces which de Laval tried to counter with his flexible shaft, would have destroyed such an engine.

Parsons had the idea of reducing the steam pressure and speed, without reducing efficiency and economy, by causing the whole expansion of the steam to take place in stages so that only moderate velocities would have to be reached by the turbine wheels. This principle still forms the basis of ail efficient steam-turbines today. Parsons put it into practice for the first time in his model of 1884, a little turbine combined with an electric generator, both coupled without reducing gear and revolving at 18000 r.p.m. The turbine consisted of a cylindrical rotor enclosed in a casing, with many rings of small blades fixed alternately lo the casing and to the rotor. The steam entered the casing at one end and flowed parallel with the rotor ("axial flow"); in doing so it had to pass between the rings of blade – each acting virtually as a nozzle in which partial steam expansion could take place, and the jets thus formed gave up their energy in driving the rotor blades.

It was a more complicated solution of the problem than de Laval's, but it proved to be the right one. The speed of 18000 r.p.m. used the energy of the steam very well, and the generator developed 75 amperes output at 100 volts. The little machine, built in 1884, is now at the Science Museum.

Parsons expected, and experienced, a good deal of opposition after all, there, were enormous vested interests in the manufacture of reciprocating steam-engines. He began to build some portable turbo generators, but there were no buyers. Strangely enough, a charity event created the necessary publicity for the turbine. In the winter of 1885–1886, a pond froze over, and a local hospital decided to raise funds by getting young people to skate on the ice and charging for admission. The Chief Constable had the idea of asking Mr. Parsons to illuminate the pond with electric lamps, powered by one of the portable 4-kW turbo-generators.

The event was a great success, and the newspapers wrote about it. The next step was that the organizers of the Newcastle Exhibition of 1887 asked Parsons to supply the current for its display of electric lighting. Parsons, who died in 1931 at the age of 76, lived long enough to see one of his turbines producing more than 200000 kW. He also succeeded in introducing his steam-turbine as a new prime mover in ship propulsion.

Until this day, the steam-turbine has held its place as the great prime mover for the generation of electricity where no water power is available. The steam which drives them hi the power stations may be raised by coal, oil, natural gas, or atomic energy – but it is invariably the steam-turbine which drives the generators. Diesel-engines are the exceptions, and are only used where smaller or mobile stations are required and no fuel but heavy oil is available. Today's steam-turbines, large or small, run at much lower speeds than Parson's first model, usually at 1000–3000 r.p.m.

When, a quarter of a century after Charles Algernon Parsons's death, the first nuclear power station in the world started up, his steam-turbines were there to convert the heat from the reactor into mechanical energy for the generators. The atomic age cannot do without them – not yet.

ADVANCED TECHNOLOGIES AND LOADING SHOVEL DESIGN

I. The use of computer-aided design systems in shovel design has been in place for many years. However, recent advances in computer capability and improved software programs and graphics are making computers even more useful.

Loading shovels are at the heart of most surface mine production. As truck sizes have increased, shovel manufacturers have matched them with larger shoves. Further increases in shovel size may be in order if trucks in the 270-t (300-st) range find acceptance at the largest surface mines.

However, larger shovels are not currently the primary focus of shovel design engineers. Competition and user pressure are combining to keep their work directed toward improved shovel productivity and efficiency. Computer design technology and advanced electronics play an increasingly prominent role in this work.

“Improved diagnostic capability, system monitoring, vibration analysis and above all increased user friendliness in machine control systems are being pursued by most manufacturers working in our industry today,” observes Stuart R. Cotterill, director of marketing for Harmschfeger Corp.

The use of computer-aided design (CAD) systems in shovel design has, been in place for many years. However, recent advances in computer capability and improved software programs and graphics are making computers even more useful.

Among other impacts, computers allow a company to bring a new shovel to the field much more quickly. Bob Griffiths, a Caterpillar design engineer, reports that “We started with the 5130 and had the machine in iron in one-a-half to two years. About halfway through that program, we started on the 5230, and a little over a year after that, that machine was in iron. It was introduced in the fall of 1994”.

“In the past, these programs might have taken three years. The biggest gains have been in turnaround times, faster computers and working concurrently in the engineering and manufacturing process.”

II. All shovel manufacturers emphasize easy access to machine service points. Walk-in access to engine and pump compartments is a design standard, as are automatic central lubrication systems. Cabs specifically designed for operator comfort and operating efficiency are also standard.

Most of the hydraulic loading shovels discussed in this article can be equipped for backhoe loading, or “mass excavation”. Such use is gaining acceptance in some applications. “We are seeing that large contract miners may be more inclined toward the mass excavator (loading backhoe),” says Paul Ludwigsen, a Caterpillar design engineer.

“Especially the Australians, who are looking at these machines for work in the western gold fields when they have a fairly homogenous ore body. They can design their bench height to take advantage of the mass excavator’s loading ability. They are also using them in the coal fields in the Bowen Basin and the Hunter Valley to chase rolling and dipping seams of coal to take away the partings. They have really worked at setting up a job to take advantage of the capability of an excavator where you can get your swing down from 20° to 25°, while for shovels, swings are usually in the range of 40° to 90°.”

CAD and other more recently designed tools are contributing to the optimization of all major shovel components. “Forty years ago mining shovels were designed by conventional means, which included generous overdesign and factors of safety to accommodate indeterminacy and unknowns,” explains B-E design engineer, B. M. Lang. “In today’s competitive world, excess “fat” has been taken out of designs.”

“Designers now rely heavily on finite element analysis (FEA) as the primary design tool to determine stress and suitability, especially in more complex areas. FEA has also become a primary tool for analysis of field problem areas,” Lang says. “Before-and-after computerized stress levels can be correlated to elapsed time when a problem occurs, to project increased component life”.

“The way computers are used in the design of mining machinery has evolved markedly in the last four years. Where we previously ran CAD programs and FEA on mainframes, we are now on the third generation of engineering workstations. The new hardware and software permit finely meshed solid element FEA models to be solved quickly," says Lang. "Where previously a plate element model was used to recover stresses adjacent to critical welds, we now model the welds themselves with solid elements".

WHY JAPAN LOVES ROBOTS AND WE DON'T

Always looking to the future, Japanese businesses are pinning many of their industrial hopes on increasing use of factory robots.

So what if robots don't pay back their investment right away?

They are a great bet for improving manufacturing quality and countering rising labor costs.

Andrew Tanzer and Ruth Simon in a factory where Matsushita Electric makes Panasonic VCRS, a robot winds wire a little thinner than a bum an hair 16 times through a pinhole in the video head, and then solders it. There are 530 of these robots in the factory and they wind, and then wind some more, 24 hours a day. They do it five times faster and much more reliably than the 3,000 housewives who, until recently, did the same job with microscopes on a subcontract basis in Japan's countryside. The robots even inspect their own work.

A U.S. company can't get this technology – even if there were an American consumer electronics industry to take advantage of it. Matsushita invented and custom-made all 530 wire-winders to gain a competitive edge.

Robots were invented here, and the U.S. still leads in advanced research, from robotic brain surgeons to classified undersea naval search-and-destroy robots. But when it comes to using robots to solve practical problems – on the factory floor and in everyday life – Japan has no equal.

What may sound like science fiction to most Americans is taken for granted by ordinary folk in Japan. The Japanese are now accustomed to having robots do everything from make sushi to perform Chopin. Ichiro Kato, a roboticist at Waseda University, designed Wabot, a famous piano-playing, music-reading robot. Says Kato: “There will be one or more robots in every house in the 21st century.”

Wabot’s creator expects to see robots in people’s homes doing dishes and washing floors. He envisions a humanoid robot with movable arms and a synthesized voice that will provide mobility and companionship to lonely old people. Kato, 64, says: “I’d like to live to see that day.” Advances in artificial intelligence will put all this in the realm of the probable.

You probably haven’t heard much about robots lately in the U.S., and for good reason. Robots have been an embarrassing disappointment for many American manufacturers. But in Japan companies of all sizes have embraced robots. The robots make it easier to quickly alter a production line to make several different product models. Japanese suppliers are in the forefront of these “flexible manufacturing systems,” in which robots play a crucial role.

Now the technology is moving beyond the factory into hospitals, concert halls and restaurants.

In 1988 Japan employed two-thirds of all robots in use in the world, and last year it installed about $2.5 billion worth of new ones. Compare this with the U.S., which added only about $400 million worth of robots last year. “The total population of robots in the U.S. is around 37000,” says John O’Hara, president of the Robotic Industries Association. “The Japanese add that many robots in one year.” To be sure, Japan has enough antiquated and small factories to leave its overall manufacturing productivity below that of the US. But robots will help narrow the lead. For example, U.S. carmakers are heavily robotized. However, the Japanese are installing new robots not simply to automate but also to make production lines more flexible. For example, Nissan’s newer auto plants can produce hundreds of different variations on a given car model simply by reprogramming robots that paint auto bodies and install car seats, engines, batteries, windshields, tires and doors. In Japan, even small companies use robots in simple applications such as welding.

It is one more example of Japan's skill at grasping a new technology and putting it to work while others dither. It happened in consumer electronics, memory chip production and machine tools. Now it's happening in robotics.

As Japan's robot population grows explosively, the U.S. market for metal employees is inching up after falling sharply in the mid-1980s. In February Deere & Co. decided to can the robots it uses to paint tractor chassis and hire humans. The robots take too long to program for endless permutations of paint orders. Whirlpool's Clyde, Ohio washing machine plant has used articulated arms that resembled the human wrist, elbow and shoulder to remove washtubs from injection molding equipment. But the complex robots aren't up to running around-the-clock production. Whirlpool gave up on the idea of using robots for this job, opting for fixed automation -a technology the U.S. excels in.

"Robots give you a lot of flexibility, but there's also a lot of complication," says James Spicer, a director of engineering operations at Whirlpool. "To lift one cylinder at a time you don't have to duplicate the motion of a human arm."

So many other manufacturers have sent robots to the junkyard or slowed plans to add new ones that the U.S. robot industry is in shambles. Early robot producers like Westinghouse and General Electric abandoned robotics in the late Eighties because of disappointing sales. And one-time highfliers such as Unimation and Industrial Systems have disappeared into bigger companies, while Prab and Automata founder under heavy losses.

One of the few profitable U.S. robot companies is GMFanuc, a 50/50 joint venture between the carmaker and Fanuc, a leading Japanese robot maker. The venture last year earned a few million dollars on sales of $165 million. Japanese producers aren't making any real money in robots, either. But many Japanese firms design and make robots for their own use to boost competitiveness and quality, so profits are not the issue. They don't buy robots based on a spreadsheet showing payback periods.

Now U.S. companies, having invented industrial robots and licensed the technology to Japan back in the 1960s, are in the awkward position of licensing back new Japanese technology. Cincinnati Milacron, number three in the U.S. robot business, aided Matsushita Electric's push into robotics by licensing it technology. Last year Milacron became a U.S. distributor for small welding robots produced by none other than Matsushita.

Why is Japan so robot-happy? It has to do with a lot more than economics. Japanese managers and government officials consider robots a key tool in combating a severe labor shortage at home. The alternatives would be moving the labor-intensive operations abroad or letting immigrants into Japan. The first alternative would deprive Japan of its manufacturing skills. "If you can fully automate manufacturing, there's no reason you have to go to Southeast Asia," argues Tadaaki Chigusa, a director of McKinsey & Co., Inc. (Japan). The second alternative, immigration, is unacceptable in the homogeneous, somewhat racist Japanese society.

While Chinese, Filipino or Korean laborers would not be very welcome in Japan, no such prejudice exists against robots. The Japanese seem to have been primed for robots with positive images in their popular culture as far back as the 1950s – much earlier than in the U.S. Japanese toymakers have churned out millions of toy robots, and the country's cartoons and comic books are filled with robot heroes. The prototype is Astro Boy, developed in Japan in 19S3 and later exported to the U.S.

"Astro Boy is as well known in Japan as Mickey Mouse and Donald Duck are here," says Frederik Schodt, author of "Inside the Robot Kingdom" (Kodansha International, 1988), which argues the Japanese have been conditioned to feel comfortable with robots from a young age. "He's a very cute, friendly robot who's always fighting for peace."

Mostly, robots are portrayed favorably in Western popular culture nowadays, from Star Wars R2-D2 to the futuristic Jetsons cartoon family. However, in Western tradition, robots have frequently been stereotyped as soulless humanoid machines or evil characters in works such as Fritz bang's 1920s silent Him Metropolis and the 1920 Czech play R.U.K. by Karel Capek, in which the word "robot" was coined to describe man-created monsters that turned on their masters.

In Japan, friendly, peace-loving robots are seen as solving a growing blue-collar labor shortage. The number of Japanese high school graduates is stagnant, and fewer graduates are willing to get their hands dirty. "Young people would rather work at the Hotel Okura or McDonald's than in the factory," says Naohkie Kumagai, associate director of Kawasaki Heavy Industry's robot division. Shirking factory work doesn't carry a heavy penalty: Last year's typical high school graduate had 2.5 job offers to choose from.

Robots are more than a mere substitute for human labor. They can do some things better than humans. "Robots are becoming indispensable because they provide a precision, quality and cleanliness man can't," says Toshitsugu Inoue, senior engineer in Matsushita's robot development department. Because robots work at a precise speed and don't make mistakes, inventories are easier to control.

As electronic components are miniaturized, robots are becoming essential for quality and high yields in the production of everything from very large scale integration chips (some of Japan's "clean rooms" are already unmanned) to watches and VCRS. The inverse is also true: Because Japanese manufacturers have robots; they can further miniaturize the product. The process is redefining the product. Many consumer electronic products are designed from scratch to be efficiently assembled by robots.

The Victor Co. of Japan JVC Ltd.'s Yokohama camcorder factory is bathed in an eerie silence. Automated guided vehicles quietly deliver pallets of components to 64 robots, which perform 150 assembly and inspection tasks. Two workers operate the robots, which assemble eight models on the same production line. Before the robots were installed in 1987, LVC needed 150 workers to do the same job. Just as important, JVC has redesigned the camcorder and its components, some almost microscopic, to be more efficiently assembled by robots. The robots also provide flexibility: They'll work around the clock – no overtime, sick leave or bonuses.

Japanese government industrial planners have since the 1970s provided a raft of incentives for robot research, development and use. The government allows accelerated depreciation for purchase of sophisticated robots and established its own leasing company to provide low-cost robots to the private sector. Japan's Ministry of International Trade & Industry provides small and medium-size companies with interest-free loans to buy robots; it is also pouring $150 million into developing hazardous-duty robots for use in nuclear power plants or fighting fires at oil refineries. This would be unthinkable in the U.S., because it smacks of industrial policy.

Politics and national differences aside, why has the U.S. lagged so far behind Japan in applying robots to manufacturing? "The companies selling robots plain lied about the capabilities of their equipment and the circumstances under which, they could perform," says Roger Nagel, manager of automation technology for International Harvester (now Navistar Corp.) in the early 1980s and now a professor at Lehigh University. After struggling for two years to debug a robot brought in to load and unload stamped parts from a press, Nagel finally junked the robot. A Japanese customer would probably have worked more closely developing the robot with the supplier, incorporating ideas from the engineers and even from assembly workers on the customer's own factory floor.

One reason for the overblown expectations is that U.S. robot engineers often came from the field of artificial intelligence and had little if any experience on the factory floor. They were enamored of the idea of a mechanical human, an idea readily embraced by corporate executives who hoped to replace workers in "lights out" factories.

TEXTS FOR RENDERING

DRY-TYPE TRANSFORMERS

While the conventional transformer is insulated by the use of oil, the dry-type unit is insulated with other materials and oil is not used. One advantage of the dry-type unit is that it can be buried in the ground, and this avoids the erection of a building to house the transformer station. Also, in underground workings, such as mines, tunnel projects, etc., the dry transformer may be mounted on wheels and brought close to the electrically-driven machines being used. This allows the machines to be supplied with current at full voltage, whereas if the transformer is a long distance away from the machines there is always a fall in voltage along the transmission lines. In towns and cities, the voltage of the electricity supply can be maintained at near the full voltage because the transformers can be buried in the ground at points near the load centre. The oil-filled transformer, on the contrary, has to be housed where a site is available, and such sites are not always conveniently situated in heavily-populated areas.

The principle of installing transformers below ground level is not new, but until recently such experiments were conducted with oil-filled transformers and difficulties is encountered with this type. One of the difficulties is the efficient dissipation of the heat generated in the transformer, for soil is a poor thermal conductor, and in practice only very small transformers can be placed underground if they are of the oil-filled type. With the dry unit, however, there is no limit to the size. The use of high temperature resistant insulation enables the size to be kept to a minimum, and at the same time, the higher air temperature makes adequate ventilation possible. As the transformer is contained in a watertight tank, it is proof against ground seepage.

The kinds of insulation used for the transformer can be divided into two groups: insulating carriers and insulating media. Glass and asbestos usually form the carriers, and various types of silicons form the insulating media. A fused mixture of glass and mica may be employed for the supporting blocks and spacers. Such types of insulation give a high degree of protection against dampness and they enable a transformer to operate in the damp underground atmosphere without the dangers associated with moisture absorption. If, however, a flashover should occur, as no organic insulation is present, there is no formation of a carbon track, such as occurs when organic materials are burned; these tracks are, of course, good conductors of electricity.

The possibility of dampness affecting the insulation in a buried transformer is further reduced by other factors. For example, if the core is energized, the core loss will keep the temperature of the windings raised above the ambient temperature. In addition, when the transformer is operating under any appreciable load, the container tank and the surrounding earth will be warm, and this will raise the temperature of the incoming ventilating air sufficiently to prevent condensation of moisture.

In the Ferranti version of the dry-type transformer the ventilating pillar, which remains above ground when the transformer is installed, is offset from the centre line of the transformer to the edge of the container tank, in order that it need not be removed should access be required to the main tank below. This means that the core and coils of the transformer can be removed from the tank without disturbing the ventilating pillar. Offsetting the pillar in this way has the additional advantage that the pillar can be installed in a wall or hedge, while the main tank containing the transformer can be placed below a pavement, verge or garden, etc. Should the pillar itself become damaged through being in its exposed position above ground, it can be repaired or replaced without affecting the transformer below. The ventilating air which is collected by the pillar is ducted down the external side of the transformer tank in two ducts which meet in a common chamber at the bottom entry to the tank. From this point the air is guided into the cooling ducts on both sides of the coils, and is removed to the ventilating pillar by means of a ducting at the top of the tank. The inlet and outlet ventilating air ducts project above ground level, so that flooding can be tolerated without water entering the tank. The function of the ventilating pillar is to separate the outgoing from the incoming ventilating air, and to prevent dirt, water, etc., entering the ventilating ducts.

The cable boxes on the transformer are placed at the ends of the tank and are inclined at a slight angle downwards, so that the minimum depth of cable burial can be achieved, while at the same time keeping the cable boxes at the top of the tank. Inclining the cable boxes at an angle also reduces the angle of bending from the horizontal of the incoming and outgoing cables, so reducing the risk of damaging the cables.

In Coal Mines

With the rapid increase in the mechanization of coal mines, the use of electric motors to drive the machinery has likewise been increased. This implies a greater use of transformers underground to supply the motors with current at the full voltage. When the electrical requirements underground were not so great, it was possible to meet the load by the use of one or more oil-filled transformers sited at some distance from the workings and in an airway where a fire from the transformer would not be likely to cause an explosion. But the greater the distance of the transformer from the points of usage, the greater becomes the voltage drop between the transformer and the motors driving the mining machinery. It is, therefore, a great advantage to have a transformer as near as possible to the load centre in the mine. With oil-filled transformers this is not possible, due to the risk of fire in the gaseous atmosphere of the mine workings. However, the problem has been solved by the introduction of dry-type transformers into the mines, and today the transformer is mounted on wheels for transport on the mine railways, and can be transferred from one part of the workings to another. In this way the motors receive current at full voltage and thus the motors can operate at the highest efficiency and maintain full output from the machinery they are driving. When the transformer is in operation, two of the four wheels can be removed to prevent movement of the unit on the rails.

While the oil-filled transformer had to be at least 300 yards from the working places in the mine, the dry-type unit can be operated in the working places themselves.

The use of dry-type transformers at the coal face is made possible by the excellent insulating materials that are now available, chiefly silicons, and these materials with other fire-resisting products. Such products enable transformers to be made which are completely moisture-proof, fire-proof, explosion-proof, and non-toxic when in use. They give to transformers the ability to withstand heavy overloads without any reduction in normal operating life.

Practical Tests

In recent tests made in Britain by the National Coal Board on the newest types of continuous mining machines, operated from conventional transformers sited at considerable distances from the machines, it was shown that the fall in voltage between the transformer and the machines at the coal-face was over 100 V; the 550 V from the transformer becoming only 450 V at the terminals of the machine motors. This poor supply of electricity to the continuous mining machines is being remedied by the systematic installation of dry-type transformers which, being flameproof, can be employed by the side of the machines they are supplying at the coal-face.

The distribution of electrical power in coal mines has had to be reorganized due to the greater number of electric motors that are now used in coal recovery. Only a few years ago, when the standard method of coal mining consisted of the use of a power-driven coal cutter to undercut the seam, only one motor was used. Filling or loading was done manually and the only electrical power needed was that for the 40 HP motor. At the present time, filling or loading is often done by machines, and these need a power supply of a magnitude greater than that for the cutter motor.

Whereas the cutting machine was the only unit using current at the coal-face, with the advent of the combination cutter and loader, together with the operation of conveyors at the coal-face: the electrical requirements in that area have increased by as much as 300 per cent. To meet these extra demands for electrical power, the underground transformer capacities had to be increased. A coal cutting machine can be supplied adequately by the use of a 150 kVA transformer, but the same machine when operating with mechanical loading and conveying will have to be supplied from a transformer of much higher capacity. The starting current of the motors operating the machines may be at least four times that of the current required to operate the motors under normal load; the transformers must, therefore, be of sufficient capacity to cope with not only the normal motor loadings but with the additional power required to start the machines.

These considerations practically rule out the possibility of employing sufficient oil-filled transformers in the confined spaces underground, particularly as these conventional transformers would have to be, for reasons of safety, at some distance from the coal-face. The modern idea is to make the transformer part of the coal-getting plant and to operate it alongside the machines at the coal-face. Another inhibiting factor in the use of the oil-filled transformer is the accentuated voltage-drop which becomes more serious as the electrical HP at the coal-face increases. This was illustrated by a test carried out by the National Coal Board in connection with a Dosco continuous mining machine, which is operated by two 75 HP motors. An oscillogram made during the test showed that the transformer was supplying current normally at 560 V, but the current reaching the machine some distance away was only a little over 400 V. This means that no matter how efficient the modern mining machine may be it cannot be operated to the greatest advantage when the transformer has to be a considerable distance from the machine.

The dry-type transformer, which solves the problem, is being adopted by the National Coal Board, and to make the unit completely safe in the gaseous atmosphere at the coal-face, it has to be sealed in a steel casing, and the latter kept as cool as possible on the outside. Even so, here is a considerable rise in temperature inside the casing; but the design and assembly of the transformer enable it to withstand this temperature. All the insulation used is of the high temperature variety and consists of an ingenious assembly of glass, asbestos, mica and silicon preparations.

By A.E. Williams, "Electrical Journal"

LIGHTNING

Before stating any of the effects of lightning, it is best to investigate the general nature of the phenomena. Consider a cloud of the shape designated in the figure, which is located in space a distance of about 1,000 ft above the surface of the earth. This cloud and the surface of the earth can be considered as two plates of a huge condenser. Because of atmospheric electricity this condenser is slowly charged up to a certain potential aboveground. The electrostatic field obtained between the cloud and the earth is illustrated in this figure. If the potential of the cloud aboveground becomes high enough, a lightning flash will occur. A lightning flash is, therefore, a short circuit upon the condenser formed by the cloud and the earth. It has been found that the maximum voltage gradient between the cloud and the earth is of the order of 100 kV per ft. As indicated in figure 4, this gradient is directly under the cloud, where the electrostatic field is uniform; but at points away from the cloud the gradient is less, being approximately 32 kV per ft at 1/4 mile, 12.4 kV per ft at 1/2 mile, and 3.6 kV per ft at 1 mile away from the point of maximum intensity.

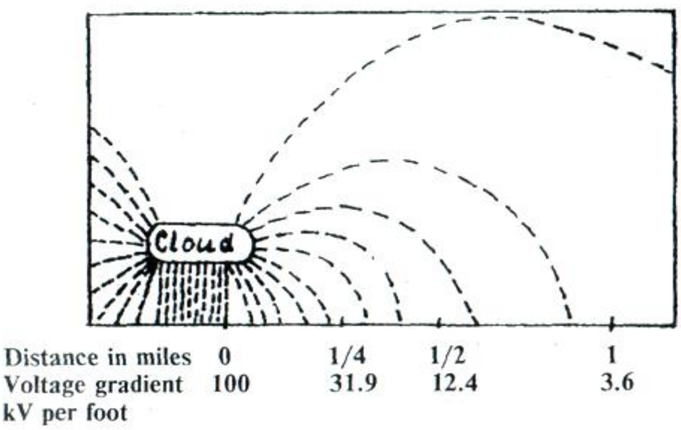

Fig. 4. Electric field and potentials in space caused by charged cloud.

As the potential of the cloud is being raised, energy is being stored at a very slow rate, but when the flash occurs, energy will be discharged very rapidly; therefore the current may be very large. At a voltage gradient of 100 kV per ft, it follows that the total potential of a cloud at 1,000 ft above ground must be 100,000,000 volts. The current in a lightning flash must be dependent on the voltage, the resistance, inductance, and capacity between cloud and ground, and also on the nature of the waveform of the discharge. It is the general belief of a good many engineers that current of the order of 20,000 to 50,000 amp in a flash are not uncommon.

By J. G. Tarboux, "Electric Power Equipment"

TYPES OF ARMATURE WINDINGS

Neglecting the homopolar machine, which represents a special type of design, direct-current generator armatures can be of the multiple, series, or combination multiple and series windings. The fundamental difference between the multiple and series windings is in the number of parallel paths obtained in the armature. The multiple winding contains as many parallel paths as the generator has main poles. The series winding contains only two parallel paths irrespective of the number of main poles. It also follows that a multiple-wound armature requires as many brush studs as the generator has main poles, while the series-wound armature requires only two brush studs irrespective of the number of main poles.

Nevertheless, in the case of large-capacity series-wound machines it is possible to use as many brush studs as there are main poles, thereby decreasing the amount of current that must be collected at each brush stud. It is obvious that the multiple-wound armature is the best suited for medium voltages and high current capacities on account of the larger number of parallel paths through the armature. Series windings, on the other hand, are used in small high-voltage machines, or where it is desirable to use only two brush studs, as, for example, in railway motors.

In multiple-wound machines, if there is any irregularity in the length of the air gap under the poles, the emf's generated in the different sections of the winding will not be equal, and the unbalanced emf will tend to cause currents to circulate through the brushes even when the machine is not carrying load. To keep these circulating currents out of the brushes, similar points of the armature winding, which should normally be at the same potential, are joined by low-resistance copper connections called "equalizer rings", and these provide a path that the circulating currents follow in preference to the comparatively high-resistance path through the brushes.

An investigation of the series winding will reveal the fact that equalizer rings are not needed, as each one of the two paths of the winding is made up of conductors under all the main poles of the generator; hence there can be no difference of voltage in the two paths. This property of the series winding is made use of in a combination multiple and series armature winding generally known as a "frog-leg winding". The frog-leg winding consists essentially of a standard multiple winding and a standard series winding placed together in the same armature slots and connected to the same commutator. An investigation of such a winding will reveal the fact that the series elements act as "equalizer rings" connecting all commutator segments that should normally be at the same potential. In other words, the frog-leg winding has equalizer connections which, in addition to equalizing the emfs of the armature, supply part of the load current delivered by the generator.

ByJ.G. Tarboux, "Electric Power Equipment"

AC GENERATORS IN PARALLEL

First let us review the fundamentals of parallel operation of generators in order to apply the principles to an extensive distribution system.

1. The terminal voltage of each generator must be equal or brought to bus voltage through a transformer, Fig. 5.

2. The generators must have the same frequency and similar wave shape. Different wave shapes will build up a voltage harmonic producing internal circulating currents.

3. The generator to be connected to the bus must be in synchronism with the line, i.e. the wave voltage of the generator and the bus must be in phase, and polyphase machines must have the same phase sequence. This is done by adjusting the speed of the incoming machine and noting the difference in phase voltage between the bus and the generator, either by incandescent lights or preferably by a synchroscope.

4. AC generators, in order to operate satisfactorily in parallel, must have prime movers with drooping speed-load characteristics. Figure 6 shows two generators connected in parallel with the speed load curve of each prime mover. The vertical line of the graph indicates the frequency or electric speed rather than the rpm, for, as we have stated, the frequency must be the same. Accordingly, a two-pole 3,600 rpm and an eight-pole 900 rpm generator have the same electric speed or frequency.

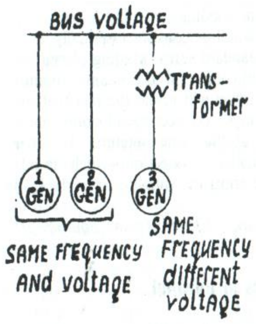

Fig. 5

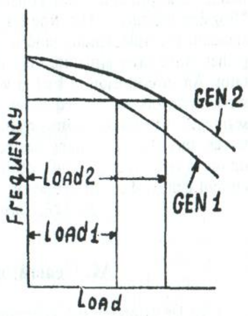

Fig. 6

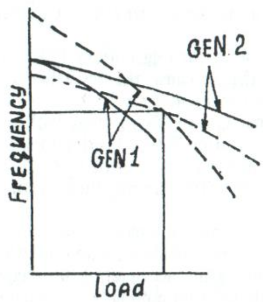

Fig. 7

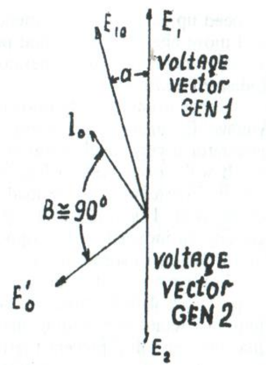

Fig. 8

At this point, it is well to emphasize the fact that, though the load between dc generators can be divided by altering the field strength, with ac generators the load cannot be changed by altering the field. To change the kw output on ac generators, the governing device on the prime mover must be adjusted. Let us assume that it is desired to increase the load of Generator 1 and reduce that of Generator 2. The speed load characteristic of Gen 1 (graph figure 6) is raised as shown in Fig. 7. Both of these generators are now delivering loads at a higher frequency. But as it is essential that the bus frequency be maintained at a fixed point (usually 60 cycles) and constant, it will be necessary that the speed load characteristics of Gen 2 be lowered at the same time as the speed load characteristics of Gen 1 are raised. This will be further covered when governor characteristics are analyzed.

Once generators are operating in parallel, they are in synchronism, that is, any changing condition tending to throw generators out of parallel will be counteracted by internal reaction opposing this tendency.

Figure 8 is a vector diagram of machines operating in parallel. Both voltages of the machines are equal and opposite so that the voltage acting in the local circuit is zero, and consequently no current is flowing in the circuit. Two generators operating in parallel must have the same average frequency, but one may momentarily run ahead or drop behind the other due to a sudden change in load. Should Gen 1 speed up slightly, the frequency will change and the voltage vector will move ahead of its normal position by angle a, shown as E_{la}. The vector sum of the two generators is no longer zero, but a quantity indicated vectorially as E_0.

Under average circumstances, the circulating current I_0 lags the voltage E_0 angle B, by nearly 90 deg, because the resistance of a generator is very small in proportion to its reactance.

It will be observed in Fig. 8 that I_0 is nearly in phase with voltage E_{la}. Therefore a power load is placed on Gen 1 tending to slow it down; while I_0 is nearly 180 deg from the voltage vector E_2 of Gen 2, causing an induced emf in opposition to the current, thus creating a motor action, to speed up Gen 2.

Consequently, if alternators in parallel attempt to pull out of step, a circulating current between the machines are set up which tends to retard the leading machine, while accelerating the lagging machine, and thus prevent the machines from pulling out of synchronism? This current I_0 is called the synchronizing current.

It has been previously stated that changing the field current does not affect the load output of the generator. If two generators are operating in parallel, but have their field adjusted to give the same terminal voltage, a reactive current will flow between the generators to compensate any difference in electric characteristics between the machines.

FUTURE POWER SOURCES

Introduction

Scientists and engineers are devoting an increasing amount of attention to what are commonly called "new" or "unconventional" power sources. The impetus for this development effort stems from many things. In a general way, the continually increasing demand for electric power, and the eventual inability of present energy sources to supply our needs are the dominant factors. However, there are others – the need for specialized power plants to serve in space or in remote land areas, to name one.

Four of the most promising of the "new" power sources – thermoelectric, thermionic and magnetohydrodynamic generators, and fuel cells – are discussed in the following pages. As most readers will recognize, none of these power generation methods are new in principle. The concept of thermoelectric devices dates back to 1822; the thermionic principle to 1878; magnetohydrodynamics to about 1835, and, the fuel cell to 1802. However, only recently have these principles come in for serious attention as the basis for large-scale power generators. The present interest stems largely from a better understanding of the physics and chemistry involved, and our ability to develop new materials to meet the unusual requirements.

In these articles no particular attempt has been made to evaluate each new generating method fully. At this stage of development, any general evaluation would be impractical, because much remains to be learned about each method.

Thermoelectric Generators

Almost 150 years ago the German physicist Thomas Seebeck discovered that the flow of heat through a metal segment could produce a voltage difference between its hot and cold ends. Although this Seebeck effect has since become familiar through its uses in instrumentation, the field of application has been severely limited because of its low voltage and power output.

The recent development of new thermoelectric materials has now changed this condition, with the result that both the power output and the efficiency of thermoelectric devices have been raised to levels suitable for the practical generation of power. A year ago, for example, Westinghouse was working with devices whose output was slightly over 1 watt; today a generator rated at 5,000 watts has been completed.

The qualities of thermoelectric devices that have impelled these developments, particularly for military applications, include raggedness and compactness and, of course, the static nature of the devices. Heat is converted into electricity without moving parts. This freedom from moving parts has several significant implications for defense; for example, in military power plants heat could be converted to electricity without noise. In space vehicles and missiles, this characteristic would permit the elimination of gyroscopic forces that occur in rotating machines and so simplify guidance and stability in orbit. An even more basic advantage is that thermoelectric generators are inherently more reliable than rotating machines and may eventually prove lower in first cost.

The Basic Phenomenon

In any uniformly heated pellet of thermoelectric material, positive and negative electrical charges are uniformly distributed, as in Fig. 9; but when heat is applied to one surface, this distribution changes. Although the positively charged ions in the crystals remain fixed, the negatively charged electrons tend to move to the cooler end. This results in a gradient of electrical charge and a potential difference between the hot and cold ends, which can cause current to flow in an external load. In actual use, thermoelectric devices are arranged in an array of series-connected thermocouples whose materials have been so formulated that their voltages are additive. Through stacking of elements in arrays, voltage outputs adequate for power generation can be achieved.

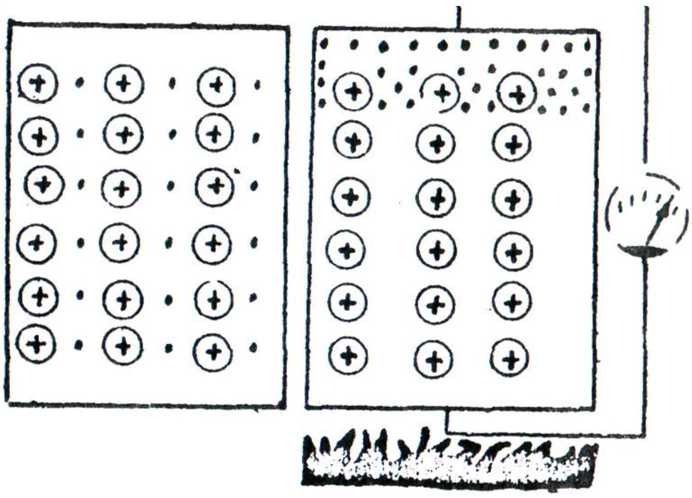

Fig. 9. Left, in a uniformly heated material, the electrons and positively charged ions are uniformly distributed. Right, distribution of electrons and positively charged ions as it is influenced over a thermal gradient. Electrons concentrate at cold end of the specimen to cause a gradient of electrical charge.

Materials and Their Parameters

An important factor in the growth of thermoelectric technology is the ability to adjust the number of free electrons in semiconductor materials. The importance of this is due to two basic relationships: First, the output voltage of any thermoelectric material is inversely proportional to the number of free electrons in that material, and, second, the conductivity of the material is directly proportional to the number of free electrons. Thus, insulators containing 10^{10} electrons per cubic centimeter generate output voltages of about 10,000 microvolts per degree centigrade of temperature difference between the hot and cold ends; offsetting this, however, is the fact that they have an extremely high internal resistance.

On the other hand, the metals give output voltages of about 5 microvolts per degree, but have extremely low internal resistance. Therefore, to obtain maximum power output or optimum efficiency from a thermoelectric material, the electron density must be adjusted to an acceptable compromise value between high voltage and high electrical conductivity. This is essential to the production of useful power since a combination of high voltage and low current or of low voltage and high current result in little power.

The compromise is shown by the efficiency curves in Fig. 10, which indicate that the optimum electron density is about $10'^{9}$ free electrons per cubic centimeter, value well within the range of good-conducting semiconductors and one that affords output voltages of about 175 microvolts per degree C. Some typical materials that demonstrate acceptable efficiency are zinc antimony, lead telluride, bismuth telluride, and germanium telluride.

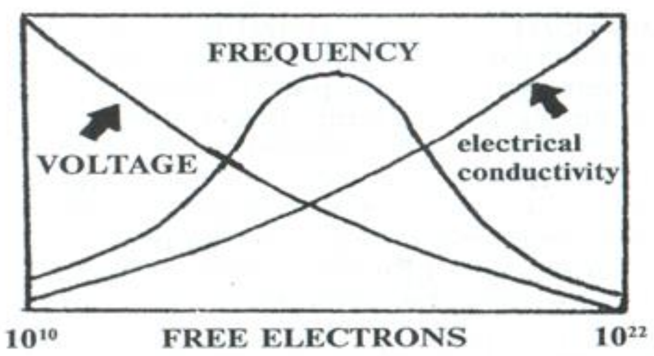

Fig.10. Curves showing the relationship between density of free electrons in a material and conductivity and thermoelectric output voltage. Optimum density for maximum power output is about $10'^{9}$ electrons per cubic centimeter.

In thermoelectric generators built for practical uses, it is desirable to use a number of different thermoelectric materials, to take advantage of the fact that each has its best range of operating temperatures. This contributes to the increased efficiency that is possible when generators are operated at high temperature. To cover low temperatures, say up to 600 degrees C, several semiconductors have proved satisfactory.

However, to go higher, say into the 1,000 degree C range, semiconductors are no longer suitable, since at these temperatures they become "intrinsic"; that is, the heat input causes both positive and negative electrical charges to migrate in equal numbers and so no output voltage is possible. As an extreme example, Fig. 11 shows how bismuth telluride's output voltage falls to zero at 150 degrees C.

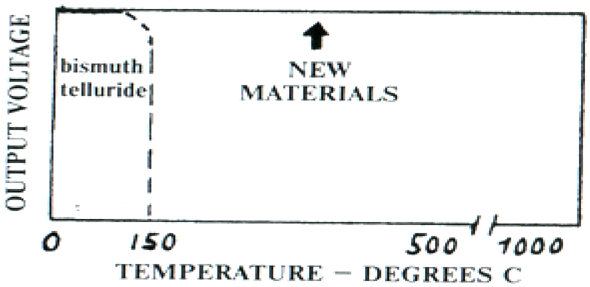

Fig 11. An illustration of the manner in which semiconductors are intrinsic at critical temperatures.

Obviously, at higher temperatures materials are required that are free of this behavior. A promising approach is the use of insulator materials that have been modified to become good thermoelectric materials. This is particularly interesting since many insulators do not become intrinsic conductors in the 1,000 degree C range. As an illustration of this modification, pure nickel oxide is normally an insulator, but if it is modified by the addition of three percent of lithium, its resistivity decreases to about 0.01 ohm-centimeters. As explanation for this, in normal nickel oxide the nickel has a valence of plus two but the addition of lithium causes the appearance of nickel with valence of plus one. The material's greatly increased conductivity is brought about by an exchange of charges between plus-one nickel and plus-two nickel. Through similar modifications, other materials are being developed for use at higher temperatures. For example, this approach led to one of the newest mixed valence materials, samarium sulphide, which has a good figure of merit at temperatures as high as 1,100 degrees C.

Devices and Design

Despite these developments, the increasing knowledge of semiconductors or mixed-valence materials does not solve all problems of thermoelectricity, for materials are not an end in themselves; they must be fabricated as thermocouples and then be assembled in finished devices. For example, assemblies of thermoelectric materials must be joined so that contact resistance is not excessive, for this would have the same effect as high internal resistivity of the material and would reduce the efficiency.

Also, above 300 degrees C, thermoelectric materials must be shielded from the air to prevent corrosion of materials and joints. Another aspect of design is the need to mount thermoelectric devices so that they will withstand shock and vibration. One method used for accomplishing this is to apply compressive forces through spring-loading.

Other design problems with high priority grow out of a desire to narrow the gap between the efficiency that is theoretically available from known materials and the efficiency that is actually available when these materials are applied in equipment. Materials available today are capable of an efficiency of about 17 percent, but when assembled as elements of complete generators, the overall efficiency then becomes about six percent. Much of this loss is due to such factors as the stack losses, represented by the discharge of heat-bearing gases from the generator's "chimney", and the fact that some of the energy transferred through the walls of the chimney passes around but not through the thermoelectric elements.

Although continued progress in generator design will reduce losses and increase total efficiency, nuclear reactors seem certain to be much more efficient in thermoelectric applications than conventional heat sources. With nuclear reactors, the heat source can be completely surrounded by thermoelectric elements to eliminate stack losses.

An interesting aspect of the efficiency of thermoelectric generators is that it is independent of power rating, which is in contrast to the power-efficiency relation for conventional machines.

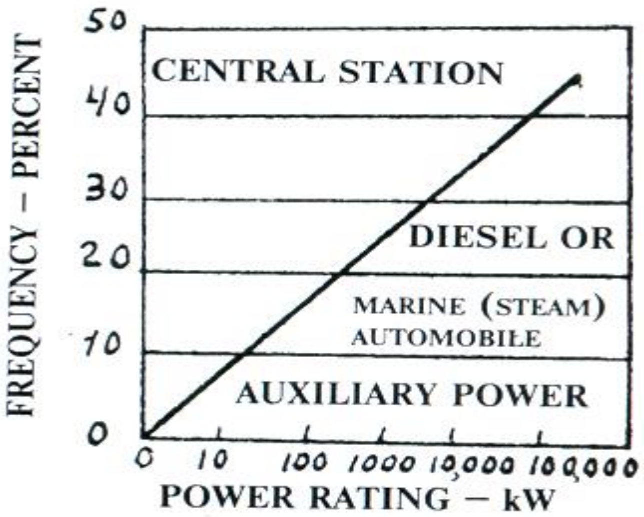

Fig 12. Efficiency of conventional heat engines as a function of their rating.

As Fig. 12 shows, small conventional power supplies have an efficiency of roughly five percent, the automobile engine is about 15 percent efficient, and large diesel engines and marine steam turbines have efficiencies of about 20 percent. As the most efficient units, large central station power plants have efficiencies of about 42 percent. At present, the efficiency of today's thermoelectric generators is constant at about six percent regardless of rating. Viewed from the standpoint of efficiency only, thermoelectric devices are thus comparable to conventional power sources in applications up to about 10 horsepower.

By S.J. Angello

THERMIONIC GENERATORS

Thermionic generators produce electrical power by using electrons emitted from the surface of a material heated to a high temperature. These generators share with thermoelectric devices the characteristic that the working fluid is electrons; they differ in that the heated electrons are emitted into a vacuum rather than into a solid. Because of the high potential difference between the interior and exterior of a solid, i.e., the "work function", thermionic generators must operate at high temperatures. Their output voltage is correspondingly higher than thermoelectric converters, ranging from 0.5 to 3 volts.

Although still in early stages of development, thermionic generators offer promise as a power source for both military and commercial applications. First, however, materials with a high heat of vaporization combined with a low work function must be found. These materials must be capable of operating for long periods of time at temperatures up to 4,500 degrees F.

At present, the thermionic generator is a concept that promises to open up new areas in power generation at high-operating temperature. For military applications where compactness, light weight, simplicity, and high efficiency are required, this device offers promise for practical use.

Principle of Operation

Consider a plate of conductive material containing electrons that are free to move and stationary positive charges. When this cathode is heated, electrons begin to move in a random jostling fashion until a number escape from the surface of the material. Facing the cathode and separated from it in an evacuated space, is the anode; an external circuit is connected between them, Fig. 13(a).

As the cathode is heated, electron activity increases and electrons escape across the vacuum to the anode. The electrons then flow through the load and through the return circuit to the cathode, thus producing electric power. The concept in this simplified diagram is not new, since emission of electrons from the surface of a heated cathode is a process long used in electron tubes.

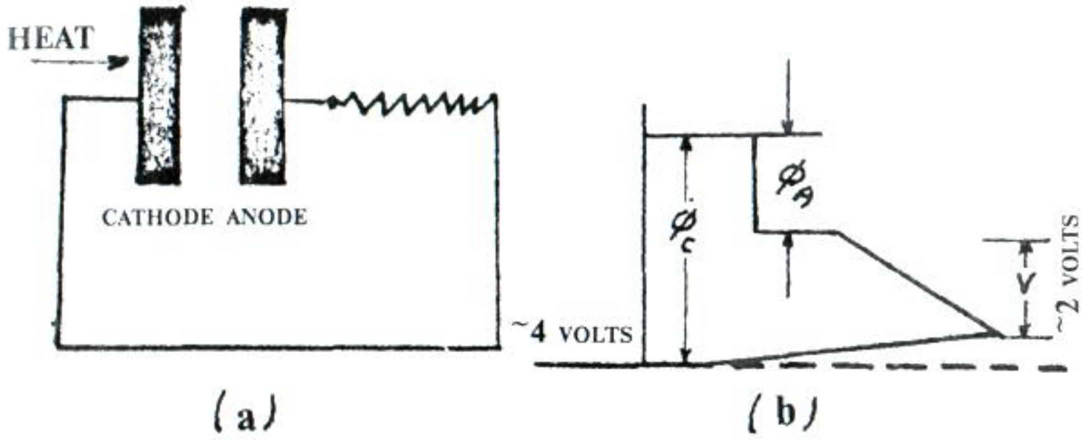

Fig. 13. (a) Operation principle of a thermionic generator. (b) Potential energy diagram of electrons of the thermionic system.

A more quantitative picture is offered by a potential diagram that corresponds to the schematic arrangement of the thermionic converter, Fig. 13(b). Here the potential energy of the electron is plotted at each point in the diagram. The potential inside the cathode material is taken as zero. The electrons inside the metal are normally prevented from escaping by a potential barrier, Φ_C, which exists at the surface of the metal.

As the electrons become heated, a few have sufficient energy to surpass the potential barrier and escape into the space between the cathode and anode. When the electron reaches the anode, it falls down the potential barrier corresponding to the anode work function, Φ_A. The energy thus released is converted into heat at the anode and is lost in the process. If the anode work function is less than that of the cathode, the remaining amount of energy, $\Phi_C - \Phi_A$, is available to do useful work in the external circuit and to supply the electrical losses in the return circuit.

Efficiency is not the only parameter of a power converter, but is certainly among the most important, for it establishes the areas of application. To be of much practical interest, the efficiency of a power converter must be at least 10 percent. To determine the efficiency of a thermionic converter, the calculated electric power output that can be delivered to a load can be compared with the total heat input. Some of this heat goes into the useful work; some is transferred to the anode by electron motion; some leaks back through the electrical connection; and most important of all, some is transferred directly to the cold end of the machine by radiation.

The efficiency of conversion depends then on such material properties as the work function, electron emission constants and radiant emissivity, and the operating temperature. The operating temperature is, in turn, limited by the melting point or evaporation rate of the cathode. Thus material properties of the anode and cathode are important in deciding whether an efficient arrangement is practical.

The available combinations of material properties that will result in the optimum device cannot be described in a simple manner. However, Fig. 14 shows some calculated efficiencies for a variety of possible cathode materials as a function of cathode temperature. These calculations, meant to be illustrative only, assume an anode reflection that gives an effective emissivity of 0.5, and an anode work function of 1.8 volts. Each curve terminates at a point where cath-ode evaporation becomes high enough to evaporate a millimeter of material from the cathode in 1,000 hours, a condition assumed to represent end of life.

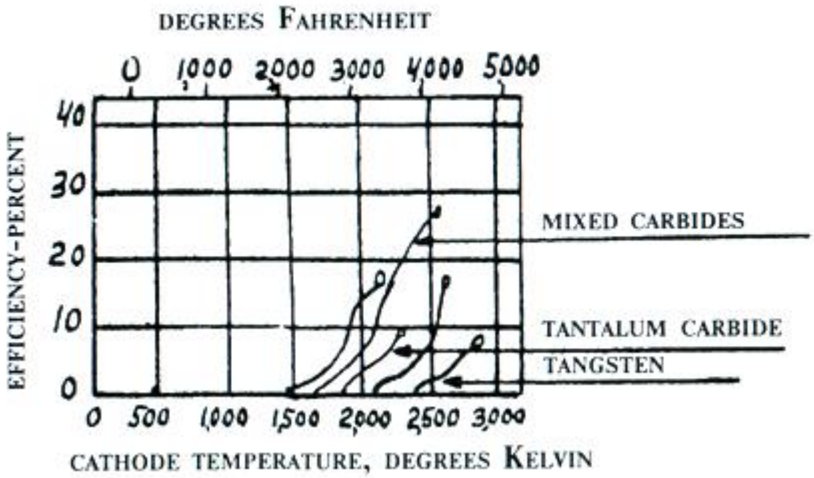

Fig. 14. Plot of efficiency vs. cathode temperature for a number of materials for thermionic generators under investigation at the Westinghouse research laboratories.

Note that each material dictates an operating temperature and that many materials reach excessive evaporation rates before interesting efficiencies can be achieved.

Another important factor determines the current flow in a thermionic converter. This phenomenon is called space charge the mutual repulsion of electrons. An electron emerging from the cathode finds itself in the company of a swarm of other electrons, all similarly charged, from which it is repelled. This will drive most of the electrons back into the cathode before they have a chance to reach the anode. One practical way for eliminating space charge consists of introducing heavy positive ions in numbers sufficient to neutralize the charge electrons.

Application of thermionic converters for the commercial generation of power appears most favorable when the thermionic element is used as a topping unit for a nuclear steam plant, thereby taking advantage of the high temperatures available from the fuel.

Thermionic conversion offers one possible means of obtaining efficient conversion of heat to electrical power. Whether it becomes competitive with other means will depend largely on the solution of problems concerning the properties of materials. In the past there has been no particular urge to find or produce materials having the peculiar properties demanded by the thermionic converter. The field is therefore largely unexplored and advances of considerable magnitude can be expected.

By John Coltman

MAGNETOHYDRODYNAMIC GENERATORS

Power from High-Temperature Gas

About 130 years ago, Michael Faraday discovered that a conductor moving in a magnetic field could be made to generate an electric current. This principle has traditionally been applied to produce electric power by mechanically rotating solid copper bars past energized field windings. However, Faraday's experiments also showed that power can be generated by substituting a flowing liquid metal, such as mercury or some other conducting liquid, for the copper bars. A device that uses a fluid conductor to produce an electric current is a magnetohydrodynamic generator.

The MHD Generator

The word magnetohydrodynamics, abbreviated MHD, stands for the branch of physics that encompasses both electromagnetic and fluid-dynamic phenomena. Practical realization of MHD power generation appears at the present time to depend on the use of a conducting gas. For the gas to be conducting, a certain number of free electrons must 'be present, along with an equal number of ions, plus the main body of unionized gas. The most direct approach to partially ionize a gas, and thereby make it conducting, is to heat it sufficiently. However, the temperatures required for sufficient gas ionization in this case are beyond the limits of use of all known materials.

However, when a gas is "seeded" with an alkali metal, such as potassium or cesium, adequate electrical conductivity can be realized at somewhat lower temperatures - in the range of 4,000 – 5,000 degrees F.

In an MHD generator, hot ionized gas travels through a magnetic field, which is applied at right angles to the flow, and past electrodes that are in contact with the stream of gas, Fig. 15. Electrons in the gas are deflected by the field and, between collisions with other particles in the gas, they make their way diagonally to one of the electrodes. An electric current is produced as the electrons move from the anode, through the load, to the cathode, and back again to the gas stream.

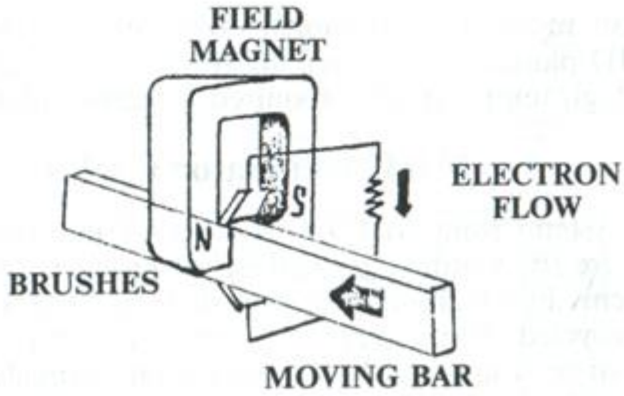

Fig. 15(A) This sketch illustrates Faraday`s original concept, which formed the basis for the unipolar / or homopolar / generator.

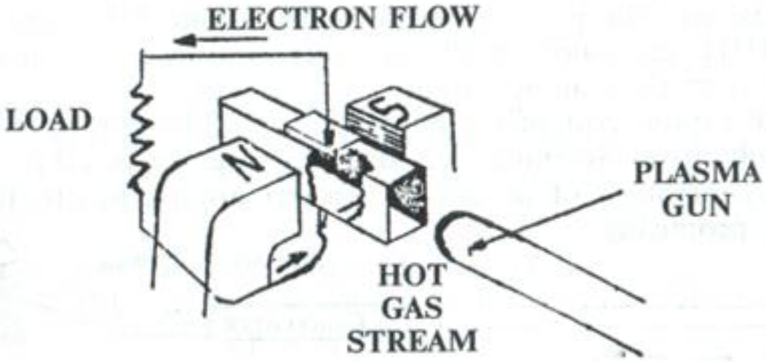

Fig 16. (B) The MHD generator employs the same principles, with a conducting gas replacing the moving bar.

The voltage at the terminals of an MHD generator is directly proportional to the intensity of the magnetic field, the gas velocity, and the distance between electrodes. A generator will supply maximum power when the load connected to its terminals has a voltage drop equal to one-half of the open circuit voltage.

Near peak power, the efficiency of a magneto hydrodynamic generator may be as low as 50 percent, because of the PR losses. But efficiencies in the 80- to 90-percent range are possible when the generator is operated somewhat below maximum power. This corresponds to the efficiency of a conventional steam turbine-generator combination, which is about 80 percent.

The overall thermal efficiency of a plant using an MHD generator might be as much as 60 percent; compared with 40 – 42 percent for the most modern conventional power plants. The high efficiency of the MHD plant arises principally from the high temperature that is used; this high temperature is required for gas ionisation.

MHD Generator Cycles

Power systems using MHD generators fall into two categories: open systems where the wording gas consists of products of combustion, and closed systems in which an inert gas, such as argon or helium, is continuously recycled. The complete system in either arrangement requires a compressor to overcome the pressure drop normally occurring in the MHD generator, and a regenerator and waste heat boiler to recoup maximum energy from the hot gas stream.

One possible arrangement for a closed-cycle MHD plant is shown in Fig. 17. The gas consists of helium, seeded with two-percent cesium. The plant shown would generate 580 megawatts. Since the MHD generator develops, direct current, a converter is required to produce an ac output.

The capital cost of the converter would be appreciable, although not prohibitive. Scientists are also studying the possibilities of direct MHD generation of ac power. Several approaches to this problem appear promising.

The MHD generator for the system shown in Fig. 17, would be 50 to 60 feet long, and would operate at about 4,000 degrees F. A reactor may be used as the heating device. However, the development problems of this reactor, or of the heat exchanger that preheats the gas stream, should not be underestimated.

A boiler is used to recover heat from the gas stream and generate steam. This steam drives a 38-megawatt turbine, which powers the gas compressor. The steam turbine is assisted by a motor, which consumes some of the MHD generator output.

To circumvent reactor development problems, two other possibilities are being considered: (1) a combustion – fired external heater could be used in the closed loop helium system of Fig. 17; or (2) an open system could be used in which the combustion gases pass directly through the MHD generator.

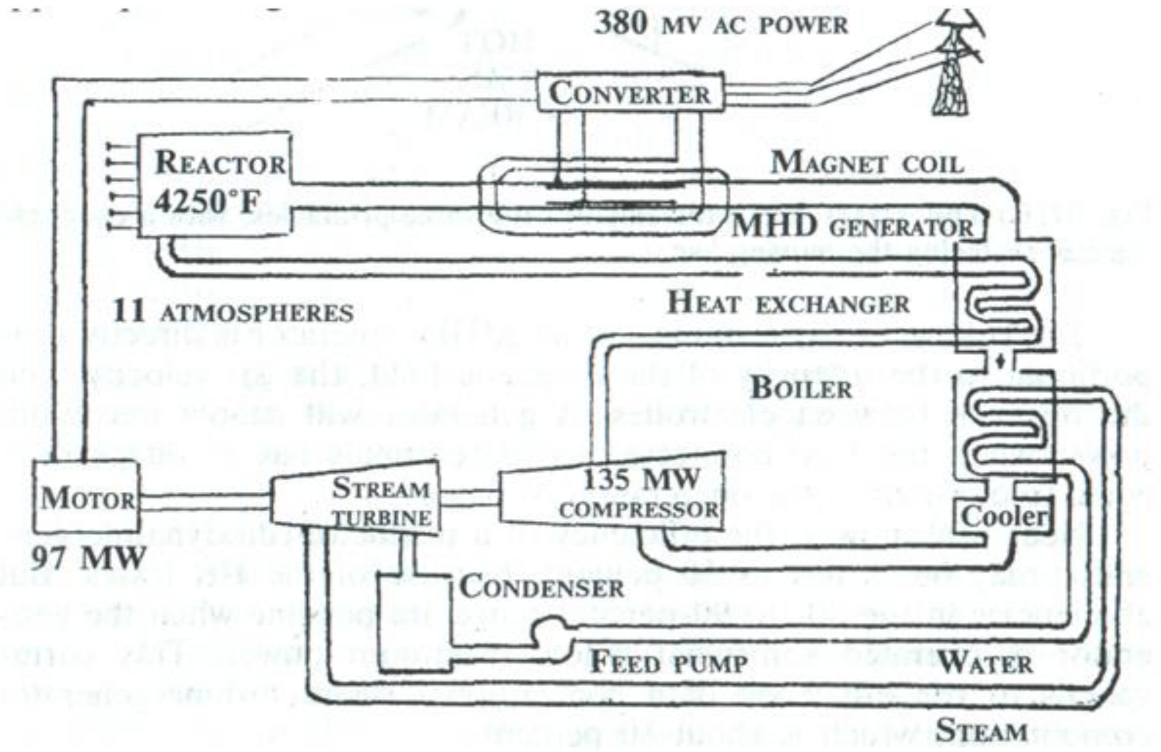

Fig. 17. A proposed 38C-mw central station plant using an MHD generator as the power source.

The latter arrangement is shown in Fig. 18.

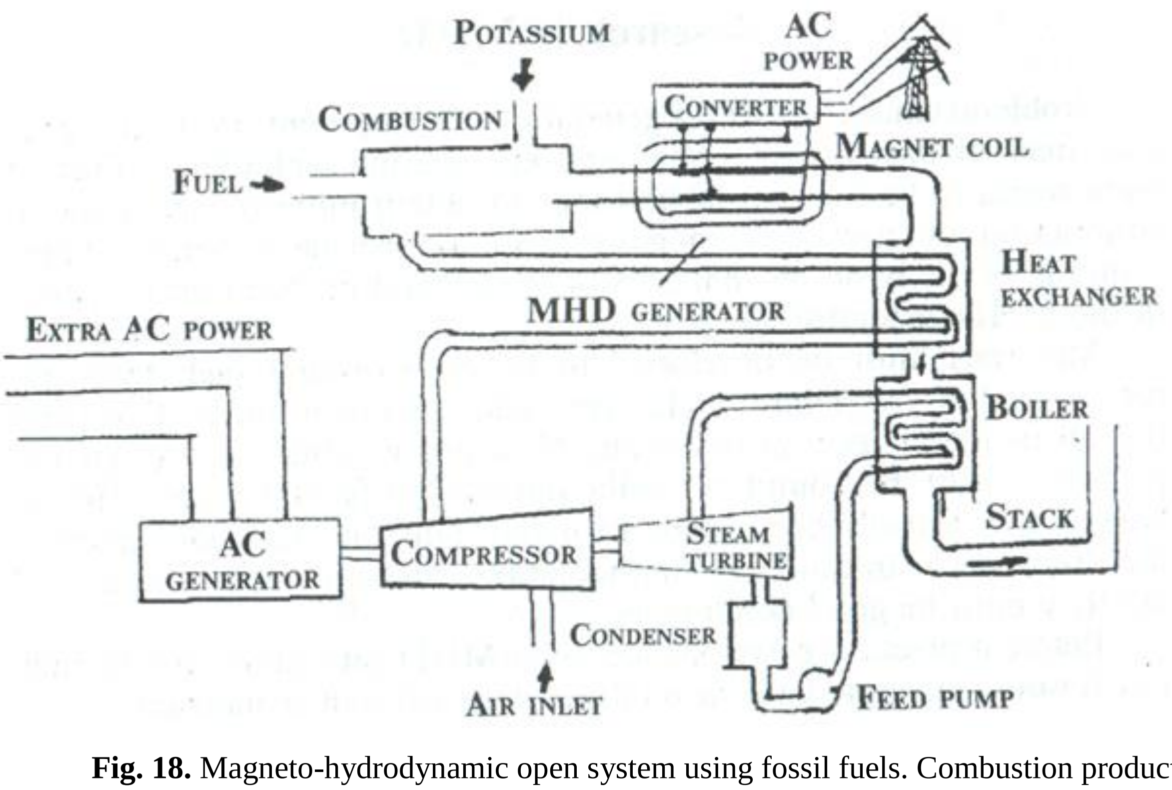

Fig. 18. Magneto-hydrodynamic open system using fossil fuels. Combustion products replace helium-cesium mixtures in conventional units.

In this case, a surplus of power can be generated in the steam loop so that an electric generator is present, replacing the dc motor used in the closed system. Operating temperatures in the MHD generator in the open system must be higher, however, because electron mobility is lower in combustion – product gases than in helium. Another difference is that potassium rather than cesium is used for seeding because cesium is too costly to discharge. In either case, means would have to be taken to avoid air pollution by the hydroxides of the seeding elements.

Research in MHD

Problems ahead in MHD generation development are in the general areas of physics, materials, and engineering technology. Further work needs to be done in laboratories to obtain more reliable data on conduction of electricity in gases, and to provide a better understanding of the basic mechanisms of energy and momentum exchange in the MHD generator.

Materials must be developed to better withstand high temperatures, sudden temperature changes, and chemical interaction with the alkali-metal seeding materials. New engineering and design approaches must be found to build durable parts of ceramic, which have conventionally been made of metal. Durable electrodes must be developed to withstand high temperatures and chemical attack, and yet they must be good conductors.

Before a practical power source using MHD generation can be built, much work remains to be done on the problems already mentioned.

By Stewart Way

FUEL CELLS

ELECTRICAL ENERGY FROM AN ELECTROCHEMICAL PROCESS

A fuel cell is similar to a battery because both convert the "free energy" of a chemical reaction directly to electrical energy by an electrochemical process. In contrast to conventional batteries, the fuel cell uses a low-cost fuel and oxidant, which are continuously fed into the system.

Several types of fuel cells exist, but they all exhibit some basic similarities to the cell illustrated in Fig. 19.

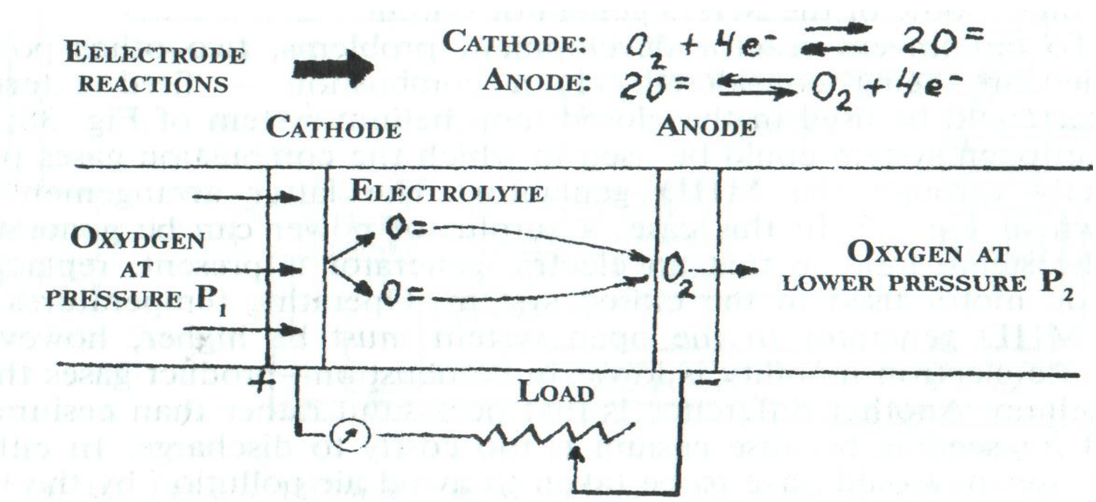

Fig. 19. Principle of operation of the oxygen concentration fuel cell.

This schematic diagram illustrates one of the simplest cells, in principle, that can be devised. It is called an oxygen concentration cell. It consists of an electrolyte that conducts an electric charge in the form of oxygen ions, but is an insulator to electrons. The electrolyte is sandwiched between two electrodes. A voltage is created between the electrodes when the oxygen is at different concentrations at the two electrode-electrolyte interfaces.

In operation, an oxygen molecule (0_2) diffuses through the porous cathode to the junction with the electrolyte, where it picks up four electrons to form two oxygen ions. The ions migrate through the electrolyte to the porous anode where they release their electrons and recombine to form an oxygen molecule. The anode that receives the released electrons is the negative electrode. The oxygen combines with a fuel or continues on into the chamber where it is exhausted from the system. If the two electrodes are connected to a load in an external circuit, a current will flow through the load. The current will continue to flow as long as a difference in oxygen concentration exists between the two electrodes.

Although fuel cells that illustrate this simplified principle are in early stages of laboratory research at present, most fuel cells involve electrode reactions that are more complicated than the simple concentration principle illustrated, and are consequently more restricted in the fuels they can use.

Operating Characteristics and Properties

The unique characteristics of the fuel cell offer many advantages for electric power generation. For example, a fuel cell system contains no moving parts, and can operate silently. Efficiency is independent of cell size over a wide range of power output, as contrasted with steam-turbine generators, which have lower efficiency at lower ratings. Fuel cells are low-voltage, direct-current devices, which makes them particularly adaptable for use in the electrochemical industries. The most interesting property of a fuel cell is that it does not operate on a heat cycle, the limiting factor in the efficiency of steam-turbine generators and other heat engines. Thus a high-temperature fuel cell system should theoretically be able to produce over twice as much useful energy from fossil fuels as today's most efficient steam-turbine generator unit.

The efficiency of the fuel cell is usually defined as:

$$\text{Efficiency} = \frac{\text{Electrical Energy Out}}{\text{Heat of Combustion of Fuel}}$$

On this basis, fuel cells can theoretically operate at efficiencies as high as 70 to 90 percent, compared with a maximum 42 percent for today's most modern central station plants.

Unfortunately this is not the complete story since cell efficiency is also a function of system load. At higher loads efficiency decreases. An economic compromise must be accepted, where efficiency and capital cost, as affected by size and weight of the cell, are optimized.

Fuel cells offer the possibility of more efficient conversion of chemical to electrical energy than conventional electric power generation methods. An ideal fuel cell would use cheap fuels, be made of economical materials, operate at high efficiency, have high power output per unit volume and weight of cell, and a long life.

By J. Welssbart, R. Ruka, "Westinghouse Engineer"

SUPPLEMENTS

RENDERING

A rendering is a brief summary of a book, an article, or other publication. The purpose of a rendering is to describe the work in such a way that the reader can decide whether or not to read the work itself. A rendering helps the reader understand the particular usefulness of each item. The ideal rendering shows the relationships among individual items and may compare their strengths or shortcomings.

The following points provide guidance for writing renderings. As appropriate each of these issues might be assessed and commented on in the rendering.

1. Qualifications of the author, unless very well known.
2. The scope and main purpose of the publication (book, article, web site).
3. The intended audience and level of reading difficulty.
4. The author's bias or assumptions, upon which the work's rationale rests.
5. The method of obtaining data or doing research.
6. The author's conclusions.
7. Comparison with other works on the same subject.
8. Materials appended to the work – maps, charts, graphs, photos, etc.
9. The work's importance or usefulness for the study of a subject.

Not all of these points are necessary for every rendering, and they certainly do not have to be noted in the order listed here, but they at least ought to be kept in mind when writing a rendering.

HOW TO WRITE RENDERING

I. Formulate the theme of information from the text using the clichés:

- the text deals with (touches upon, is devoted to, describes),
- the main idea of the texts is to show (to analyze, to describe).
- Determine the sphere of knowledge this information belongs to.

II. Process the information given in the text in the following way:

a) divide the text into some parts according to its content;

b) write out a number of key-words to each part of the text;

c) retell each part using the keywords;

d) determine the main idea of the text;

e) retell the text in 10–12 sentences.

III. Give the summary of each paragraph using key words and language clichés:

it is reported about the development of (the improvement of, the experiment in the field of, the results of, a new design of, the characteristics of);

details of design (technology, process) are given; it is told in details about;

a brief description of … is given;

it is told in short about;

special (much) attention is given (is paid) to;

it is specially noted that;

some facts (figures, terms, characteristics) are given.

IV. Present your rendering of the text according to the following structure.

1. Sphere of knowledge this information belongs to.
2. The theme of the text.
3. Summary of the text.

ABSTRACT

An abstract is a condensed version of a longer piece of writing that highlights the major points covered, concisely describes the content and scope of the writing, and reviews the writing's contents in abbreviated form. There are two types of abstracts are typically used:

1) descriptive abstracts – their purpose is to tell readers what information the report, article, or paper contains;

2) informative abstracts – their purpose is to communicate specific information from the report, article, or paper.

Writing an abstract you may use the following steps:

1. Reread the article, paper, or report with the goal of abstracting in mind. Look specifically for these main parts of the article, paper, or report: purpose, methods, scope, results, conclusions, and recommendation.

2. Use the headings, outline heads, and table of contents as a guide to writing your abstract.

3. If you're writing an abstract about another person's article, paper, or report, the introduction and the summary are good places to begin. These areas generally cover what the article emphasizes.

4. After you've finished rereading the article, paper, or report, write a rough draft without looking back at what you're abstracting.

5. Don't merely copy key sentences from the article, paper, or report: you'll put in too much or too little information.

6. Don't rely on the way material was phrased in the article, paper, or report: summarize information in a new way.

7. Revise your rough draft to correct weaknesses in organization.

8. Improve transitions from point to point.

9. Drop unnecessary information.

10. Add important information you left out.

11. Fix errors in grammar, spelling, and punctuation.

HOW TO WRITE ABSTRACT

I. Formulate the theme of information from the text using the following clichés:

the text deals with (touches upon, is devoted to, describes).

II. Process the information given in the text in the following way:

a) divide the text into some parts according to its content;

b) write out a number of key-words to each part of the text;

c) retell each part using the key-words;

d) determine the main idea of the text;

e) retell the text in 10-12 sentences.

III. Find out author's conclusion in the text; write it down using the following clichés:

- the author concludes with a consideration of,
- the author comes to the conclusion that,
- in conclusion the author says that.

IV. Give your own comments on the information from the text. Try to answer the questions:

a) how do you evaluate the actuality of this information;

b) how do you think who and for what purposes could use it.

Use the following clichés:

- `the information of the texts is addressed to the students (graduates, engineers, specialists, all those interested in);
- the texts may be recommended to;

- the information of the texts is interesting (important, useful, hard to understand).

V. Present your abstract of the information from the text according to the following structure:

1. The theme of the text.
2. The main idea of the text.
3. Summary of the text.
4. Author’s conclusion.
5. Your own comments.

THE SCHEME OF RENDERING THE ARTICLE

1. The headline of the article

The article (we deal with) is headlined (entitled)... – статья (с которой мы имеем дело) озаглавлена…

The headline of the article (under consideration) is the following... – заголовок статьи (которую мы рассматриваем) следующий…

The title of the article is… – заголовок статьи…

2. The author of the article

The author of it is... – её автор …

The article (under consideration/ under review) is written by... – статья, которую мы рассматриваем, написана…

3. Where and when the article was published

It is published (printed) in... – она опубликована (напечатана) в...

It is a first (second) page article – это статья первой (второй страницы)

The article is published under the rubric... – статья опубликована под рубрикой

4. The main idea of the article.

The article is devoted to the problem... – статья посвящена проблеме...

The article (author) deals with the problem of... – статья (автор) имеет дело с проблемой...

The author of the article dwells on the certain idea of… – автор подробно останавливается на...

The author concentrates on... – автор концентрируется на...

The article (briefly) touches upon... – статья (коротко) затрагивает...

The purpose of the article is... (to give information to the reader) – цель статьи...

The aim of the author is to provide the reader with some material of... – цель автора – обеспечить читателя материалом...

5. The content of the article (With my own simultaneous commentary)

The problem revealed... – раскрытая проблема...

The author starts by telling the reader about... – автор начинает с того, что говорит читателю о...

The author writes, considers, points out, etc. – автор пишет, полагает, выделяет, и т.д.

According to the problem of the article I should... – в соответствии с проблемой статьи я должен

The author reports that... – автор сообщает, что...

In conclusion... – в заключении...

The author concludes with the following... – автор делает вывод (заключает) следующим...

The author comes to the following conclusion... – автор приходит к следующему заключению...

The author sums up by telling... – автор суммирует следующим...

Summing everything up the author says… – суммируя все, автор говорит…

6. Our own opinion of the article. (My understanding, opinion of the article)

I found the article… – я считаю статью…

important – важной

acute – острой

actual – актуальной

dull – скучной

of no value – не представляющей из себя никакой ценности

worth attention – стоящей внимания

not up to my age – не по моему возрасту

quite to the point – как раз кстати (по теме, к делу)

I express approval of… (support of…) – я выражаю одобрение… (поддержку…)

I express alarm (concern, disappointment) … – я выражаю тревогу (озабоченность, разочарование)…

I strongly protest against… – я протестую против…

Neutral Arguments

The article draws attention to the fact that... – статья обращает внимание на тот факт, что...

The paper finds a good deal to say... – в газете много говорится о…

In the author's view (opinion)... – помнению автора

The author brings out the problem of... – автор выносит на рассмотрение проблему…

The author describes... – авторо писывает…

The author points out... – автор выделяет…

The paper comments on – газета комментирует...

The article focuses its attention on (the fact that) … – статья фокусирует внимание на (том факте, что) …

As the paper puts it... – как излагает газета...

In its comment the paper reviews… – в своем комментарии газета обозревает...

CONVERSATIONAL PHRASES

Agreement

I think (believe so) – думаю, что это так

I suppose so – полагаю, что это так

I quite agree with you here – я в этом с вами полностью согласен

Absolutely – конечно, точно, именно

Yes, indeed – да, в самом деле

You are right (right you are) – вы правы

Of course – конечно

Sure – конечно

Certainly – конечно

No doubt – без сомнения

It goes without saying – само собой разумеется

That's right – правильно

There's no doubt about it – в этом нет никакого сомнения

Looks like that – похоже на это

There's no denying it – это нельзя отрицать

I won't deny it – я не буду это отрицать

That's it – точно

Most likely – наверняка

Exactly – точно, конечно

I fully agree with you – я с вами полностью согласен

I can't help agreeing with you – не могу не согласиться с вами

Beyond all doubt – вне всякого сомнения

True enough – верно

By all means – обязательно, во что бы то ни стало

Disagreement

I don’t agree (with you here) – я не согласен (с вами в этом)

I can’t agree with you here – я не могу согласиться с вами

I don’t think so – я так не думаю

I’m afraid not – боюсь, что нет

I disagree with you – я не согласен с вами

You are wrong – вы неправы

You are mistaken – вы ошибаетесь

By no means – ни в коем случае

Rubbish – чепуха

Nonsense – нонсенс

It’s far from it – это далеко не так

Just the other way round – как раз наоборот

On the contrary – наоборот

I hardly think… – не думаю, что

Absolutely wrong – совершенно неправильно

Excuse me, but… – простите, но

That’s not right – это неправильно

Of course not (certainly not) – конечно нет

Nothing of the kind – ничего подобного

I’m not (so) sure – я не уверен

I doubt it – сомневаюсь в этом

I object to it – я возражаю

I see what you mean, but… – я понимаю, что вы имеете ввиду, но…

I see your point here, but… – я понимаю вас, но…

I don’t think it’s quite right – я не думаю, что это правильно

INTRODUCTORY PHRASES

Actually… – дело в том, что; фактически; на самом деле…

In fact… – дело в том, что…

As a matter of fact… – дело в том, что…

The fact is… – дело в том, что…

First of all (at first, to begin with) I'd like to say… – для начала я бы хотел сказать…

If you ask me… – я думаю, что…

As for me… – что касается меня …

In my opinion… – по моему мнению…

As I see it… – как я понимаю …

To tell the truth… – по правде говоря …

Frankly speaking… – честно говоря …

Generally (speaking)… – в общем говоря …

Practically (speaking)… – на самом деле …

As far as I know… – насколько я знаю …

As far as I remember… – насколько я помню …

I think (believe)… – я думаю …

I suppose… – я полагаю …

Fortunately… – к счастью …

Unfortunately… – к несчастью …

Sorry to say… – к сожалению …

Evidently… – очевидно …

And besides… – и кроме того …

What's more… – более того …

Moreover… – более того …

Further on I'd like to say, that… – далее я бы хотел сказать, что …

On the whole… – в целом …

It is interesting to note… – интересно отметить …

I’d like to remark… – мне бы хотелось отметить …

As a result… – в результате …

On the one hand (on the other hand) – с одной стороны… (с другой стороны)

To be more exact… – если быть более точным …

In addition… – в добавлении …

Nevertheless… – тем не менее …

I’m inclined to think… – я склонен думать …

No wonder… – не удивительно …

Today I am going to talk about... – сегодня я собираюсь поговорить о...

I am going to give you a very general view on... – я собираюсь дать вам общее представление о...

The subject of my talk is... – предмет моего разговора...

Today I shall be dealing with... – сегодня я буду иметь дело с...

I am going to discuss the question of smth ... – я собираюсь обсудить вопрос о...

I should like in particular to talk about… – я бы хотел в особенности поговорить о...

The aspect I intend to concentrate on is... – аспект, на котором, я намериваюсь сконцентрироваться...

The area I hope to cover is concerned with... – область, которую я надеюсь охватить связана с...

What I hope to do is to show how/what... – что я надеюсь сделать, это показать как/что...

The aim of my talk is to show that... – цель моего разговора показать, что...

There are (three) main points I intend to make... – я намериваюсь сделать (три) главных пункта...

There are (three) areas I’d like to deal with... – я бы хотел иметь дело с (тремя) областями...

Then I’d like to move on to... – далее я бы хотел перейти к...

The next point I’d like to mention is... – следующий пункт, который я хотел бы упомянуть...

Another aspect I want to discuss concerns... – следующий аспект, который я хочу обсудить, касается…

The first point I want to make is... – первый пункт, который я хочу сделать...

Perhaps I could just point out right at the beginning, that... – возможно, я бы мог выделить с самого начала, что…

I’d like to start by talking about… – я бы хотел начать, говоря о...

Another problem is... – другая (следующая) проблема...

Now I’d like to move on to the question of... – сейчас я бы хотел перейти к вопросу...

Lastly, there’s a matter of… to be considered. – в конце, нужно рассмотреть вопрос...

I am sure you will agree, that... – я уверен, вы согласитесь, что...

You may disagree, but... – вы можете не согласиться, но...

It is common knowledge, that... – это общеизвестно, что...

Before I end… – перед тем, как я закончу...

There is quite a lot more to say about..., but I hope I have managed to cover the main points. – Еще много чего можно сказать о..., но я надеюсь, мне удалось охватить главные пункты.

And by way of conclusion I’d like to point out, that… – и в качестве заключения я бы хотел выделить,что...

In short we can say, that... – коротко, можно сказать, что...

To summarize what I have said so far... – суммируя все, что я сказал...

To sum it up... – суммируя...

In conclusion let me remind you... – в заключении позвольте мне напомнить вам...

Let me conclude by saying that... – позвольте мне сделать вывод (заключение), говоря, что...

In conclusion I'd like to repeat/emphasize (point out) that... – в заключении я бы хотел повторить / подчеркнуть, что...

GRAMMAR REFERENCE

The Participle

The form	Active	Passive
Simple Participle	reading	being read (3форма)
Perfect Participle	having read (3 ф.)	having been read (3 ф.)

Simultaneous actions	**Prior Actions**
<u>P I Simple Active</u> *Making* a tour of England we were struck by its “park like” appearance.	<u>P I Perfect Active</u> *Having decided* to get a general idea of the country we began to study the map.
<u>P I Simple Passive</u> The monument *being erected* now on this square will be soon unveiled.	<u>P I Perfect Passive</u> *Having been presented* with five gold coins, Judy went shopping.

Participle I

Function	Form	Examples	Notes
1. An Attribute	P I Simple Active & Passive	The *roaring (бурлящая)* water of the river made a deep impression on him. (перед определяемым словом) Great Britain is situated on the British Isles *lying* to the west. (после определяемого слова) The country *being*	1. Причастие I в качестве определения может стоять как перед, так и после определяемого слова. 2. Кто-то, сделавший что-то → Причастие не ис-пользуется, а только при-даточное предложение. The boy *who had visited the USA*, told a lot about it.

		shown on the map now is Great Britain.	
2. A Predicative	P I Simple Active	The answer of the student *is disappointing (разочаровывающий)*	to be astonishing (изумленный) to be disappointing to be exciting to be humiliating to be inviting to be tempting to be terrifying
3. A Parenthesis (вводное предложение)	P I Simple Active	Judging by his words he has visited Great Britain. Generally speaking the best way to get a general idea of a country is to study the map.	generally speaking judging by appearance (words) mildly speaking (saying) speaking frankly strictly speaking saying nothing of roughly speaking

4. An Adverbial modifier of time **when?**	All forms	*While getting* breakfast ready, the girls began to light the camp fire. *Being thanked* for his help, he left.	1. Действие, выраженное причастием в функции обстоятельства, всегда относится к подлежащему всего предложения. 2. Союзы **when** и **while** часто употребляются с P I Simple Active для выражения действия, происходящего одновременно с действием, выражаемым глаголом-сказуемым. *While making* a tour of England, we were impressed by its beauty. 3. P I Simple глагола **to be** не используется в функции обстоятельства. Придаточные предложения типа *когда он был в Москве* переводим → *when in Moscow*.
5. An Adverbial modifier of cause (reason)	All forms	*Not knowing* the topic well, he got confused. *Having been left* alone, the child felt miserable and lonely.	**why?**

An Adverbial modifier of attendant circumstances (of manner)	P I Simple Active	He was standing on the top of the mountain *admiring* the beautiful view. I spent the morning on the cliff *reading*.	**in what manner?** **how?** (союз «и»)
An Adverbial modifier of comparison	P I Simple Active	He was silent for a while, *as though pausing* for a reply. She shivered with fright *as if realizing* the danger.	**as if** **as though**

Participle II the 3d form of the verb (driven, done, looked)

Function	Form	Examples	Notes
1. An Attribute	P II	People *treated* in polyclinics are called out-patients. (после определяемого слова) After giving the boy the *prescribed* medicine I went out. (перед определяемым словом). I took the boy for a walk up the path *covered* with *faded* leaves.	1. P II переходных глаголов имеет значение пассивного залога: a broken toy a locked door 2. P II непереходных глаголов обозначает переход в другое состояние: fades leaves withered flowers vanished jewels fallen trees retired captain

2. A Predicative (part of a compound nominal predicate)	P II	He *seemed delighted* to see me again. She *looked worried*. I confessed I *was bewildered*.	Составное именное сказуемое состоит из глагола-связки: **be, look, get, grow, seem, turn, remain…** + сказуемое (которое может быть выражено **P II**).
3. An Adverbial Modifier of time **(when?)**		*When told* the fare, he realized he couldn’t afford the tour.	В функции обстоятельства P II имеет то же подлежащее, что и сказуемое всего предложения.
4. An Adverbial Modifier of condition **(if)**		*If sent* immediately, the telegram will be delivered in time.	
5. An Adverbial Modifier of comparison **(as if, as though)**		He looked bewildered *as if told* something unbelievable.	
6. An Adverbial Modifier of concession		*Though frightened*, he didn’t show it.	

Participial Constructions

The Absolute Participial Construction

I. The Absolute Participle Construction with P I (non-prepositional)

Абсолютный причастный оборот с Причастием I без предлога

E.g.: **He having left** the room, **she** sat down at the table.

Когда он покинул комнату, она села за стол.

The Absolute Participle Construction with P I (non-prepositional) = = существительное или местоимение в именительном падеже + любая форма P I.

Данный оборот в предложении выполняет функцию обстоятельства образа действия, причины, времени.

He looked through the window, his glance traveling around.

They didn't play in the morning, it being Sunday.

The work being finished, they went into the shop.

Данный оборот переводится с помощью придаточного предложения.

II. The Prepositional Absolute Participle Construction with P I

Абсолютный причастный оборот с Причастием I с предлогом

E.g.: He went into the house, **with his heart beating fast**.

Он вошел в дом, и его сердце бешено колотилось.

The Prepositional Absolute Participle Construction with P I = = предлог **with +** существительное в именительном падеже или местоимение в объектном падеже (him, me…) + P I.

Абсолютный причастный оборот с Причастием I с предлогом в предложении выполняет функцию обстоятельства образа действия.

He sat with his hands lying on the table.

I won't speak with him steering at me.

III. The Absolute Participle Construction with P II (non-prepositional)

Абсолютный причастный оборот с Причастием II без предлога

E.g.: **The preparation completed**, we started off.

Когда приготовления были закончены, мы отправились в путь.

The Absolute Participle Construction with P II (non-prepositional) =
= существительное или местоимение + P II.

Данный оборот в предложении выполняет функцию обстоятельства образа действия, причины, времени, условия.

He sat on the sofa, his legs crossed.

This said, he turned his back.

My attention distracted, I didn't notice her.

This once done, he will repeat.

IV. The Prepositional Absolute Participle Construction with P II

Абсолютный причастный оборот с Причастием II с предлогом

E.g.: She went on reading **with her eyes fixed** on the pages.

Она продолжала читать, и ее глаза были прикованы к страницам.

The Prepositional Absolute Participle Construction with P II =
= предлог **with +** существительное в именительном падеже + P II.

Данный оборот в предложении выполняет функцию обстоятельства образа действия.

It's unhealthy to sleep with the windows shut.

Self-Training Exercises

I. Translate the sentences into Russian and explain the difference between P I and P II. Define the functions:

1) That man reading a book is the most capable specialist in our laboratory. The book read by the teacher was about the heroes of our country.

2) The man showing the diagrams is our teacher. The diagram shown above is very interesting.

3) Translating the text we learn a lot of new words. The text translated by the student contained many words.

4) I studied the book on physics written by our teacher. Writing the exercise I understood how to use the Participle.

II. Translate into English using the P II:

1) Полученные (to obtain) results had great importance.
2) Пройденные (to pass) kilometers were very difficult.
3) Известный (to know) address helped us greatly.
4) Услышанная (to hear) melody made me recall my youth.
5) Оставленная (to leave) clothes were in bad condition.
6) Вымытая (to wash) plate has broken to pieces.

III. Define the Participial Construction with P I after the determinate word. Note that Participles should be translated in the tense in which the predicate of the main clause is used:

1) They were looking at the children playing in the garden.
2) The substance affecting a magnetic field was metallic.
3) The scientists following this technique investigated some phenomena of radioactivity.
4) The metals being electrical conductors will make very suitable electrodes.

5) The acceleration of a body is proportional to the force causing it.

6) The relative density of a gas is equal to the molecular weight of the other gas (usually hydrogen) being used as the standard.

7) The volumes of gases entering into or resulting from a chemical reaction may be represented by a simple ratio of small numbers.

8) The remaining light, coming as it does from the edge of the sun, is much altered in quality, so that both sky and landscape take on a strange colour.

9) Under these conditions we may treat the corpuscle as consisting a group of waves having nearly identical frequencies.

IV. Define the Participial Constructions with P I, translate the sentences:

1) Counting the net charges on each atom of the two compounds, reckoning an electron which is shared between the atoms as contributing half of its charge to each, the following scheme is obtained.

2) Several rays of light are shown passing from medium 2 to medium 1 in which their velocity is greater.

3) Rising from a substance illuminated by certain rays these particles can be observed.

4) To the writer's knowledge similar rocks have not been reported as existing elsewhere.

5) While isolating and separating radium, Mme Curie found other radioactive elements.

6) It is a matter of common observation that light is refracted when passing from one medium into another.

7) Solonchak soils as morphological units are rare, occurring, when they do, in step positions.

V. Translate the sentences. Define the Participial Constructions with Perfect Participle:

1) Having become familiar with the main laws of static, we can study the laws of dynamics.

2) Having accepted this set of laws, we can predict many things about the union of chemical substances.

3) Having obtained the necessary compound, we could finish our experiment.

4) Having mixed these two substances, we put the mixture into a clean test-tube (пробирка).

5) Mendeleyev should be regarded as having discovered the law of periodicity of the chemical elements.

6) Having described in a general way what is meant by an electric current, the next step is to introduce quantitative measures for such currents and their effects.

The Gerund

Герундий представляет собой неличную глагольную форму, выражающую название действия и обладающую как свойствами существительного, так и свойствами глагола. В русском языке соответствующая форма отсутствует.

Герундий имеет формы времени и залога:

The form	Active	Passive
Simple Gerund	reading	being read (3 ф.)
Perfect Gerund	having read (3 ф.)	having been read (3 ф.)

Simultaneous action	Prior action
Simple Gerund Active Simple Gerund Passive	Perfect Gerund Active Perfect Gerund Passive

E.g.: I am surprised at **hearing** this. – Я удивлен слышать это.

I don't remember **having seen** him before. – Я не помню, чтобы я его раньше видел.

Признаки герундия

Перед герундием (в отличие от причастия) могут стоять:

1. Предлог (by, in , of, without, on, instead of, in addition to, for, after, before и др.): Excuse me **for being** so late. – Извините, что я так опоздал.
2. Притяжательное местоимение (my, your, her, his, its, our, their): I don't mind **your going** there. – Я не против того, чтобы ты туда пошел.
3. Существительное в притяжательном падеже: I don't mind **Peter's going** there. – Я не против того, чтобы Петр туда пошел.

Перевод герундия на русский язык

Герундий переводится на русский язык следующими способами:

1. Именем существительным: **Reading** English books every day will improve your knowledge of the language. – Ежедневное **чтение** английских книг улучшит ваше знание языка.

2. Инфинитивом (неопределенной формой глагола): She is afraid of **bathing** there. – Она боится **купаться** там.

3. Деепричастием: He went away without **leaving** his address. – Он уехал, **не оставив** своего адреса.

4. Глаголом в личной форме. В этом случае герундий переводится на русский язык придаточным предложением. Такие придаточные предложения *часто* начинаются словами *то, что (чтобы).* Указательное местоимение *то* может стоять в различных падежах*:* She reproached herself **for having said it**. – Она упрекала себя за **то, что сказала это.**

The Gerund can be used:

Function	**Form**	**Examples**	**Notes**
1. Subject	All forms	Flying is a thrilling thing. **It**'s no use discussing this problem now. Ones he starts making jokes **there is no** stopping him.	Герундий, выполняющий функцию подлежащего, может стоять после сказуемого. В этом случае перед сказуемым стоит местоимение **it,** выражение **it's worth** или оборот **there is no.**
2. Predicative	Simple Gerund A. & P.	What he loves best in the world **is going** to the theatre.	*глагол связка to be + Gerund*

3. Part of a Compound Verbal Predicate: a) part of a compound verbal modal predicate	 Simple Gerund A. & P.	 I **can't help telling** you about it. – Я не могу не сказать вам об этом.	 Герундий образует часть составного глагольного модального сказуемого с выражением **can't help** – не могу не.
b) part of a compound verbal aspect predicate	Simple Gerund Active	The audience **burst out applauding**	Наиболее употребительные глаголы, в сочетании с которыми герундий образует составное глагольное аспектное сказуемое: to keep on, to go on, to give up, to leave off, to burst out, to finish, to stop, to cease, to begin, to start, to continue (обычно выражают начало, продолжение и конец действия).
4. A Direct Object (прямое дополнение)	All forms	I remember **having seen** him before. – Я помню, что видел его раньше.	После глаголов: to mention – упоминать, to remember – помнить, to mind – возражать

5. A Prepositional Object (предложное дополнение)	All forms	When do you think **of going** there? – Когда вы думаете поехать туда?	После глаголов, прилагательных, причастий, требующих определенных предлогов: to depend on (upon) – зависеть, to result in, to insist on – настаивать на, to object to – возражать, to succeed in – иметь успех в, to think of, to hear of, to be fond of, to be proud of, to be interested in.
6. An Attribute (определение)	All forms	There are different ways **of solving** this problem. – Имеются различные способы разрешения этой проблемы.	Обычно после определяемого слова с предлогом **of** или **for.**
7. Adverbial Modifier: a) of time b) of manner c) of attendant circumctances	Simple Gerund A. & P. S. Ger. A. & P. S. Ger. A. & P. S. Ger.	**Before crossing** the road, stop and look both ways. She spent the whole evening **in packing.** He put the letter away **without reading** it. This hall is used **for**	**When?** in (on, upon), before, after, at **How? In what manner?** by, in without, besides, instead of **For what? For what**

d) of purpose	A. & P.	**dancing.**	**purpose?** for
e) of condition	S. Ger. A. & P.	You will never speak good English **without learning** English.	**On what condition?** without, in case of
f) of reason	All forms S. Ger.	He was in hospital **for having been run** by a car.	**For what reason? Why?** for – из-за, for rear of – из страха, что, owing to – благодаря, through – по причине, because of – из-за
g) of concession (уступки)	A. & P., Perf. G. (A)	**In spite of being tired**, he continued working.	**In spite of what? – несмотря на что?** In spite of

Exercises

I. Complete the following sentences using the Gerund

Model: **She cannot read English without…**

She cannot read English without consulting a dictionary.

1. My friend went home instead of…
2. The students went on…
3. When the teacher entered the classroom the students stopped…
4. Have you finished…
5. I went to bed after…
6. The friends spoke of…
7. You must turn the light off before…

II. Translate the following sentences using the Gerund.

1. Прежде чем делать опыты, необходимо проводить наблюдения.
2. Много лет назад люди научились защищать свои дома от ударов молнии.
3. Существуют различные способы получения электрического тока.
4. Ученые продолжали изучать новое явление.
5. Пирометр используется для измерения температуры горячих металлов.
6. Франклин изобрел громоотвод для защиты зданий от ударов молнии.
7. Ходить пешком очень полезно.
8. Атомный реактор используется для получения атомной энергии.

III. Find the Gerund in the text, define its function:

IV. a) Fill in the blanks with suitable verbs, wherever necessary.

b) Answer the following questions:

1. What … the earliest manifestation of electricity?
2. What … electricity?
3. What … the early Scandinavians think about thunderstorms?
4. Who … burning millions of tons of coal?
5. What property … Thor's hammer?
6. Who … invented the lightning conductor?
7. What experiments … Lomonosov and Rihman make?
8. What device … constructed by Rihman?
9. Who … constructed the first measuring device?

V. What questions are answered by the words in bold type in the following sentences?

1. Benjamin Franklin made his kite experiment.
2. Nobody understood that phenomenon.
3. The story of his kite is known all over the world.
4. On a stormy day Franklin and his son went into the country.
5. The key was connected to the lower end of the string.
6. Soon the kite was flying high among the clouds.
7. The electric sparks proved that lightning is a discharge of electricity.
8. The wet string conducted the electricity.
9. Franklin invented the lightning conductor.

VI. Translate the following sentences paying attention to both, both…and:

1. The students made two experiments: they were both interesting and useful.
2. Both scientists studied atmospheric electricity.
3. Both of us will work in the Institute laboratory tomorrow.
4. Both Lomonosov and Rihman were great scientists; both of them worked at atmospheric electricity.
5. Both these devices were constructed in Moscow.
6. Electricity is used both in industry and in everyday life.
7. Both nuclear power and solar energy will be widely used in the future.
8. Lightning and atmospheric electricity are one and the same thing: both of them are used in literature.
9. Many scientists and inventors; both Russian and foreign, have greatly contributed to the development and practical application of the electric current.
10. Both chemical energy and mechanical energy can be changed into electricity.

VII. Fill in the blanks with prepositions:

1. It is dangerous to go … a stormy day.

2. Lightning is a very great flash … light resulting … a discharge … atmospheric electricity.

3. Protecting building … lightning was the first discovery … the field … electricity used … the good … mankind.

4. … thousands … years people knew nothing … thunderstorms.

5. Lightning flashes are followed … thunder which can be heard … kilometers around.

6. There is always some danger … a thunderstorm … a very high building or a man standing … the open field.

7. It is difficult to see a single drop … water … the sea.

8. Some scientists … the past melted metals … the help … solar furnaces.

9. Modern civilization cannot do … electrical appliances.

10. The electric current is necessary … the operation … trolleybuses, buses and modern trains.

VIII. Form five sentences combining suitable parts of the sentence given in columns I and II:

I	II
1. Generator	a) measures the temperature of hot melted metals.
2. Lightning conductor	
	b) lifts objects weighing thousands of tons.
3. Battery	c) turns electrical energy into mechanical energy.
4. Electric crane	d) protects buildings from lightning strokes.
5. Pyrometer	e) turns mechanical energy into electrical energy.

IX. Translate into Russian:

(a) the only son; the only example known; the only method of solving the problem; only you can do it for me; coal is not only a source of heat, but also a source of valuable chemical substances; the letter was sent only yesterday;

(b) many students were present; at the present time; the present article; he is in Moscow at present; that is all for the present; good-bye for the present.

X. Describe Franklin's kite experiment.

XI. Give a short summary of the text.

INFINITIVE

Инфинитив (неопределенная форма глагола) – это неличная форма глагола, которая выражает действие безотносительно к лицу и числу.

Формальный признак инфинитива – частица «to» (to ask, to write).

Формы инфинитива

Выражают действие одновременно с действием, выраженным глаголом-сказуемым		**Active**	**Passive**
	Indefinite	to write	to be written
	Continuous	to be writting	—
Выражают действие, предшествовавшее действию, выраженному глаголом-сказуемым	Perfect	to have written	to have been written
	Perfect Continuous	to have been writing	—

Функции инфинитива в предложении

Function	Examples	Translation	Notes
1. Subject	*To acquire* knowledge is everybody'***s duty.***	Приобретать знания – долг каждого.	а) переводится инфинитивом; б) переводится существительным.
2. Object	He likes to spend is holiday in the South. He forced her to go with him.	Он любит (что?) проводить каникулы на юге. Он заставил, чтобы она пошла с ним.	а) инфинитивом; б)придаточным предложением.
3. Part of the compound nominal predicate	The problem is to do every thing without delay. The arm of our research is to find the necessary data.	Проблема – сделать все без промедления. Цель нашей исследовательской работы заключается в том, чтобы найти необходимые данные.	Глагол **to be** переводится *«заключается в том, чтобы»* или совсем не переводится.

4. Attribute	Substractures to resist the flow of current are called insulators. He was the first to come. The problem to be solved is of great importance.	Вещества, которые оказывают сопротивление току, называются изоляторами. Он вошел первым. Задача, которая должна быть (будет) решена имеет большое значение.	Переводится глаголом-сказуемым определительного придаточного предложения. Обычно после слов *«the first, the second, … , the last»* переводится личной формой глагола **to be**, в том времени, в котором был глагол **to be**, сам глагол **to be** не переводится. Переводится определительным придаточным предложением, причем его сказуемое имеет модальное значение долженствования или относится к будущему времени.

5. Adverbial modifier	To work I must have all the necessary equipment. Some molecules are large enough to be seen in the election microscope.	Чтобы работать, я должен иметь все необходимое оборудование. Некоторые молекулы достаточно большие, чтобы их можно было увидеть в электронный микроскоп.	Инфинитивом с союзом *чтобы.* Существительным с предлогом. Если пассивный инфинитив в функции обстоятельства стоит после имени прилагательного, он имеет модальный оттенок и переводится на русский язык с добавлением глагола *«мочь».*

Exercises

The Subjective Infinitive Construction	1. He is supposed to work at this plant. 2. She seems to know English well.
The Objective Infinitive Construction	1. We suppose him to work at this plant. 2. I saw the water boil.

I. Translate the following sentences and define the Infinitive constructions:

1. Lightning was proved to be a discharge of electricity.

2. The reader is certain to know that alternating voltage can be increase and decreased.

3. Heat is known to be a form of energy.

4. We know the electrons to flow from the negative terminal of the battery to the positive one.

5. This scientist is said to have been working on the problem of splitting atoms.

6. I heard this instrument meet the industrial requirements.

7. The students saw the thermometer mercury fall to the fixed point.

8. Coal is considered to be a valuable fuel.

9. We know many articles to have already been written on that subject.

II. According to the models given below form sentences combining suitable parts of the sentence given in columns 1, 2, 3, 4.

Model A: **The current is known to consist of moving electrons.**

1	2	3	4
Professor Rihman	-was observed	-to have started	-by man of 25 centuries ago, or so
Amber	-is known	-to have been observed	-for Moscow on foot
Lomonosov	-is said	-to have been killed	-minute, light objects after rubbing
Electrical effects	-is known	-to attract and to hold	-in English-speaking countries
The Fahrenheit scale	-are known	-to be used	-by a stroke of lightning

Model B: **We know lightning to be a discharge of electricity.**

1	2	3	4
We know	-Galileo -the charges -the electric current -alternating current -the Russian scientists -static electricity	-to be -to have invented -to flow -to produce -to have been -to have greatly contributed	-positive and negative -important effects -an air thermometer -first in one direction and then in another -to the science of electricity -the only electrical phenomenon observed by man

III. Translate the following sentences using the Infinitive:

1. Чтобы быть хорошим инженером, необходимо много читать и учиться.

2. Пирометр используется для измерения температуры горячих металлов.

3. Человек научился расщеплять атомы для того, чтобы получить большое количество энергии.

4. Ученые пытаются решить проблему, связанную с новыми явлениями электричества.

5. Громоотвод – это металлическое приспособление для защиты зданий от молний.

6. Проводить опыты с атмосферным электричеством было очень опасно в то время.

7. Намагнитить предмет – это значит поместить его в поле магнита.

ENGLISH-RUSSIAN DICTIONARY ON POWER ENGINEERING

A

ability	способность
achievement	достижение
add	прибавлять, присоединять
adjust	регулировать; устанавливать
advertise	рекламировать
air	воздух
all other circumstances being equal	при прочих равных условиях
all over the world	во всем мире
alternately	поочередно
alternating current	переменный ток
amount	количество
amount to	доходить до
an odd succession of scientists	ряд ученых, не связанных между собой
animal tissue	живая ткань
appliance	прибор
application	применение
approach	подход
armature	якорь
around 1500 A. D.	около 1500 г. н. э.
around the turn of the century	на грани двух веков
as a matter of fact	действительно, на самом деле
as for	что касается
as soon as	как только
as well	также
as well as	так же как
at a result	в результате

at least	по крайней мере
at once	сразу, немедленно
at present	в настоящее время
at rest	в покое
at right angles	под прямым углом
at the throwing of a switch	при включении рубильника
at will	по желанию
attract	привлекать, притягивать
B	
bare wire	оголенный провод
battery	батарея
because it works 'cold'	потому что она не нагревается во время работы
because of	из-за, вследствие
before long	очень скоро
behave	вести себя, работать
below	ниже, внизу
belts and pulleys	ремни и блоки
benefit	выгода, польза
body	тело
boil	кипеть
boiling point	точка кипения
bonding sites	свободные связи
broad	широкий
brush	щетка
bucket-shaped blades	ковшеобразные лопасти
burn	сжигать
but so far ahead of his time	но он настолько опередил свое время
by overhead cables	по воздушному кабелю
by-products	побочные продукты

C

cable	кабель
calculate	рассчитывать, вычислять
capacity	мощность; способность; емкость
carry	нести; пропускать (ток)
carry out	проводить
cause	вызывать, заставлять; причинять
cell	элемент
certain	некоторый; определенный
change	изменять, преобразовывать
channel	канал
charge	заряд
chemical	химический
chemistry	химия
closed circuit	замкнутая цепь
coal	уголь
coil	катушка
coil of pipes	змеевик
cold-jet injection	вспрыскивание струи холодной воды
collision	столкновение
come into contact	соприкасаться
commutator	коллектор
compared with	по сравнению с
complete	замкнутый; полный
compression	сжатие
condition	условие; состояние
conduct	проводить
connect	соединять, связывать
consider	рассматривать; считать

considerable	значительный
consist of	состоять из
constant	постоянный
construct	строить, создавать
consumer	потребитель
contain	содержать
continue	продолжать
contribution	вклад
control	управлять, контролировать
conventional	обычный, общепринятый
convert	превращать, преобразовывать
cool	охлаждать
copper	медь
cord	шнур
core	сердечник
cotton gin	хлопкоочистительная машина
covalently bonded carbon atoms	ковалентно связанные атомы углерода
cover	покрывать
credit for its discovery is given	честь его открытия принадлежит
current	электрический ток
D	
damage	разрушать, повреждать
dangerous	опасный
data	данные
dead centre	мертвая точка
deal with	иметь дело; рассматривать
decisive 'break-through'	решающий момент
decrease	уменьшить, понижать
degree	градус; степень

deliver	доставлять
desirable	желательный
destroy	разрушать
detect	обнаруживать, открывать
determine	определять
develop	развивать, разрабатывать
develop heat	выделять тепло
development	развитие
device	прибор, приспособление
diehards	консерваторы
difference	разность, разница
direct current	постоянный ток
direction	направление
discharge	разряжать
discover	открывать, обнаруживать
distribution	распределение
do not appear out of the blue	"как гром среди ясного неба"
do without	обходиться без чего-либо
drive	приводить в движение
due to	благодаря, вследствие, из-за
E	
effect	действие, влияние; результат
efficiency	эффективность; кпд
electric(al)	электрический
electrical engineering	электротехника
electrify	электрифицировать; электризовать
electromotive force	электродвижущая сила
emit	излучать, выделять, испускать
employ	использовать, применять

engineer	инженер
engineering	техника
enterprise	предприятие
equipment	оборудование
establish	учреждать, организовывать
excess	избыток, излишек
exist	существовать
expansion	расширение, увеличение
expect	ожидать; рассчитывать
expensive	дорогой
experience	испытывать; претерпевать
explain	объяснять
explore	исследовать, изучать
F	
facility	сооружение, оборудование
famous	известный
far apart	на расстоянии
fault	повреждение, авария
'feed-back' devices	приборы с обратной связью
field	поле; область (науки, техники)
field winding	обмотка возбуждения
finally	наконец
find out	выяснять; понимать
fire	огонь; пожар
first application of mass production methods	первое применение методов промышленного (массового) производства
fit	соединять, подгонять
flow	течь
flux	поток

follow	следовать (за)
force	сила
free	свободный
freezing point	точка замерзания
friction	трение
fulfil	выполнять
furnace	печь, горн
fuse	предохранитель
G	
gas-blast system	система, основанная на взрыве газа
gear wheels	зубчатые колеса
Geiger counter	счетчик Гейгера
generally	обычно
generally speaking	вообще говоря
generate	производить, вырабатывать, генерировать
generator	генератор
glass	стекло; стакан
great deal	значительно
growth	рост, увеличение
H	
harness	использовать энергию (воды, ветра, солнца)
heat	тепло, теплота
hence	следовательно
high-precision engineering	устройства высокой точности
his famous kite-and-key experiment	свой знаменитый опыт с воздушным змеем и ключом
I	
implementation	выполнение, осуществление
in addition to	вдобавок, в дополнение

in case	в случае
in certain respects	в некотором отношении
in motion	в движении
in no time at all	мгновенно
in one's turn	в свою очередь
in question	обсуждаемый, о котором идет речь
in spite of	несмотря на
in the form	в виде
increase	возрастать; увеличивать
indicate	показывать, указывать
induction coil	индукционная катушка
induction motors	индукционные моторы
influence	влиять
inject	вводить, впрыскивать
input	вход; подводимая мощность; входной
install	устанавливать, монтировать
instead of	вместо
insulation	изоляция
interact	взаимодействовать
into the national grid	в национальную энергетическую систему
introduce	вводить
invent	изобретать
investigation	исследование
ionize	ионизировать
Iron	железо
K	
kind	вид, род
knowledge	знания

L

laboratory	лаборатория
lack	нуждаться
last	сохраняться, длиться
launch	запускать
law	закон, право
leak off	утекать
light	утекать
like	подобный, похожий, как
likely	вероятно
liquid	жидкость
load	нагрузка
local hospital decided to raise funds	местная больница решила извлечь выгоду
lose	терять

M

machinery	машины, механизмы
magnetism	магнетизм
maintain	обслуживать, содержать
make reference	ссылаться на, упоминать
make up	состоять
make use	использовать
master	овладевать
matter	вещество, материя
mean	значить, означать
means	средство
measure	измерять
meet requirements	удовлетворять требованиям
mention	упоминать
mercury	ртуть

mighty	мощный, могущественный
missing bonding electron	дефектный электрон
mission	задача, полет
more or less	более или менее
moreover	более того
most would-be turbine inventors	большинство мечтавших изобрести турбину
motion	движение
movement	движение
N	
name after	называть в честь
natural	естественный
needle	стрелка
needless to say	нечего и говорить
negative	отрицательный
negligible	незначительный, пренебрежимо малый
nevertheless	тем не менее
no longer	больше не
note	отмечать
now and then	время от времени
nozzle	сопло
nuclear	ядерный, атомный
number	число; номер
numerous	многочисленный
O	
observation	наблюдение
obtain	получать
of getting rid of	освободиться от
offer resistance	оказывать сопротивление
on the basis of	на основе

on the one hand	с одной стороны
on the other hand	с другой стороны
on the spur of the moment	экспромтом
open circuit	разомкнутая цепь
operate	работать, действовать
opportunity	благоприятная возможность
output	выходная мощность; выходной
overheat	перегревать
P	
particle	частица
pass	пропускать
path	путь; контур электрической цепи
peaceful	мирный
per capita	на человека; на душу населения
perform	выполнять, совершать
phenomenon	явление
physics	физика
place	помещать, класть
play a part	играть роль
point out	указывать
pole	полюс; столб, опора
positive	положительный
possess	обладать
potential difference	разность потенциалов
power	энергия; держава
predict	предсказывать
present	представлять
pressure	давление
previously	ранее, предварительно

primary	первичный; первичная обмотка трансформатора
principal	основной, главный
produce	производить, создавать, выпускать
prominent	выдающийся, известный
promote	способствовать, содействовать
properly	должным образом, правильно
property	свойство
protect	защищать
prove	доказывать
provide	снабжать, обеспечивать
purpose	цель, намерение
put into operation	вводить в действие
put into use	вводить в действие, запускать

Q

Quantity	количество

R

random	беспорядочный, случайный
range	диапазон
rare earths	редкоземельные металлы
rate	скорость
rated capacity	номинальная мощность
reach	достигать
reason	причина, основание
reciprocating movement	возвратно-поступательное движение
reduce	понижать, уменьшать
relation	связь; отношение
reliable	надежный
remember	помнить, вспоминать

remove	удалять, устранять
repel	отталкивать
replace	заменять
represent	представлять
require	требовать
research	исследование
resist	сопротивляться, противодействовать
resistivity	удельное сопротивление
return	возвращаться
reverse	изменять на обратное, реверсировать
revolutions	оборотов в минуту
rise	подниматься, возрастать
rotate	вращать(ся)
rubber	резина
rule	правило
S	
safety device	предохранительное устройство
satisfactory	приемлемый, удовлетворительный
scale	масштаб; шкала
scientific	научный
secondary	вторичный, вторичная обмотка трансформатора
semiconductor	полупроводник
serve	служить, обслуживать
short circuit	короткое замыкание
shunt	шунт; шунтовой
similar	одинаковый, похожий, однородный
single	один
size	размер

socket	розетка, патрон (электролампы)
solar	солнечный
solve a problem	решать задачу, проблему
source	источник
source of supply	источник питания
speed	скорость
squirrel-cage motor	мотор типа беличьего колеса
stable elements	устойчивые элементы
statement	утверждение; формулировка
stationary	неподвижный, стационарный
stay	оставаться, жить
steam power plant	тепловая электростанция
steel	сталь
step down	понижать
step up	повышать
stepping stone	как первый шаг, как трамплин
straight	прямой
stroke of luck	большая удача
subject	предмет; тема
substance	вещество; материя
successfully	успешно
suddenly	вдруг, внезапно
sufficiently	достаточно
supply	снабжать, обеспечивать
suspend	подвешивать
switch	выключатель
T	
take place	происходить, иметь место
take time	занимать время

tend	стремиться, иметь тенденцию
tension	напряжение
term	термин
terminal	зажим, вывод, клемма
that is to say	то есть, иными словами
the former	первый из упомянутых
the latter	последний из упомянутых
the rest	остаток; остальной
theory	теория
thermionic converter	термоионный преобразователь
time and labour saving appliances	электроприборы, экономящие время и труд
torque	момент, пусковой момент
transform	преобразовывать
transmit	передавать (электроэнергию)
travel	путешествовать
trouble	неисправность, повреждение
truly	поистине
try	пытаться; испытывать
turn	виток
turn off	выключать
turn on	включать
twitching effect	эффект сокращения мышц
U	
under consideration	рассматриваемый
unit	установка, агрегат
unless	если не
unlike	разноименный

V

valuable	ценный
value	величина
variety	разнообразие
various	различный
velocity	скорость
vessel	котел реактора
voltage	напряжение
voltaic pile	гальваническая батарея

W

waste	потеря, пустая трата
watch television	смотреть телевизор
waterfall	водопад
wave	волна
weight	вес
well above	намного выше
white-hot	раскаленный добела
whole	целый, весь
willy-nilly	волей-неволей
winding	обмотка
wire	провод
withstand	выдерживать

APPENDIX

СПИСОК СОКРАЩЕНИЙ, ЧАСТО ВСТРЕЧАЮЩИХСЯ В НАУЧНО-ТЕХНИЧЕСКОЙ ЛИТЕРАТУРЕ ВЕЛИКОБРИТАНИИ И США

Сокращение	Полное обозначение	Перевод
abr.	abridgment	краткое изложение
a. h.	ampere-hour	ампер-час
a..m.	ante meridiem *(лат)*	до полудня
amp	ampere	ампер
at. wt.	atomic weight	атомный вес
b.p.	boiling point	точка кипения
Br. P.	British Patent	Британский патент
b. s.		1. обе стороны, двусторонний; 2. смотри на обороте
bu	bushel	бушель = 36,4 л
C	centigrade	стоградусная температурная шкала (Цельсия)
c.	cent	цент
cal.	calorie	калория
cap.	capacitance	1. емкость; 2. емкостное сопротивление
c. c.	cubic centimetre	кубический сантиметр
c. c. w.	counterclockwise	против часовой стрелки
cf.	confer	сравни
c. f. т.	cubic feet per minute	кубических футов в минуту
c.g.	center of gravity	центр тяжести

Ch.	chapter	глава
Cp	candle power	сила света в канделах
C R. O.	cathode-ray oscillo-scope	электронно-лучевой осциллоскоп
cu.	cubic	кубический
CW	clockwise	по часовой стрелке
d.	density	плотность
db	decibel	децибел
d. c.	direct current	постоянный ток
deg.	degree	1. степень; 2. градус
doz.	dozen	дюжина
e.g.	exempli gratia *(лат.)*	например
E. M. F; emf	electromotive force	электродвижущая сила
etc.	et cetera (лат.)	и так далее
F	Fahrenheit	температурная шкала Фаренгейта
f.	foot; feet	фут; футы
fig-	figure	рисунок, чертеж
FM	frequency modulation	частотная модуляция
f. p. m.	feet per minute	футов в минуту
G. A. T.	Greenwich apparent time	истинное время по Гринвичскому меридиану
gr.	gramme	грамм
hf. h.	half-hard	средней твердости
Hi-Fi, hi-fi	high-fidelity	высокая точность
hp	horse power	лошадиная сила
i. e.	id est (лат.)	то есть
kg.	kilogram	килограмм
km.	kilometre	километр

kva.	kilovolt-ampere (kilovar)	(столько-то) реактивных киловольт-ампер
kw.	kilowatt	киловатт
kwh; kw-hr	kilowatt-hour	киловатт-час
l.	litre	литр
lb.	libra (лат.) = pound	фунт (453,6 г)
LH	left-hand	левосторонний, с левым ходом
m.	metre	метр
mi.	mile	миля
mm.	millimetre	миллиметр
mol. wt.	molecular weight	молекулярный вес
m. p. h.	miles per hour	(столько-то) миль в час
N	normal	нормальный; число, номер
NBC	National Bureau of Standards	Национальное Бюро Стандартов
No	number	номер
oz.	ounce	унция (28,35 *г)*
P.	power	мощность
p.	page	страница
p. m.	post meridiem *(лат.)*	(во столько-то) часов пополудни
p. s.	per second	в секунду
psi.	pounds per square inch	фунтов на квадратный дюйм
R. F.	radio frequency	радиочастота
r. p. m	revolutions per minute	оборотов в минуту
s.	shilling	шиллинг
sec.	second	секунда
s/n	signal to noise	отношение «сигнал-шум»
sp. gr.	specific gravity	удельный вес

sq.	square	квадратный
sq. ft.	square foot	квадратный фут
Tee	T-type	Т-образный
tn	ton	тонна
TV	television	телевидение
viz	videlicet *(лат.)*	то есть, а именно
vol	volume	том
vs.	versus *(лат.)*	против; в сравнении с
yd.	yard	ярд (91,44 см)

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