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English for Technical Students

К. Ш. БРИСКИНА,
М. Ф. ЗАВАДСКАЯ

Английский язык для технических вузов

ИЗДАНИЕ ТРЕТЬЕ,
ПЕРЕРАБОТАННОЕ
И ДОПОЛНЕННОЕ

Допущено Министерством
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КИЕВ
ГОЛОВНОЕ ИЗДАТЕЛЬСТВО
ИЗДАТЕЛЬСКОГО ОБЪЕДИНЕНИЯ «ВИЩА ШКОЛА»
1977

Учебное пособие состоит из 9 частей и приложения. Текстовой материал подобран из технической английской и американской литературы по радиотехнике, электротехнике, физике, электронике, вычислительной технике, автоматике, электроприборостроению и знакомит учащихся с достижениями отечественной и мировой науки и техники и научной деятельностью выдающихся ученых.

В приложение входят комментарий к текстам, список наиболее употребительных в научно-технической литературе словосочетаний и фразеологических оборотов, список сокращений и символов и англо-русский словарь общетехнических и специальных терминов.

3-е издание выгодно отличается от второго новыми текстами по радиоэлектронике, кибернетике и вычислительной технике. Включены упражнения на закрепление специальной терминологии, упражнения на составление аннотаций и рефератов и на перевод их с русского языка на английский.

Учебное пособие рассчитано на студентов технических специальностей вузов.

Редакция литературы по иностранным языкам
Зав. редакцией М. М. Азаренко

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ПРЕДИСЛОВИЕ

Данное учебное пособие предназначается для студентов 2-го, 3-го и частично 4-го курсов электротехнических, радиотехнических, физических факультетов и факультетов вычислительной техники технических вузов, университетов и педагогических институтов. Это пособие может быть использовано и для работы с аспирантами.

Цель пособия — подготовить студентов к чтению, пониманию специальной литературы на английском языке, привить им навыки аннотирования и реферирования, а также навыки устной речи в пределах проработанной тематики.

Пособие построено на материале современных технических журналов по вышеуказанным специальностям и книг английских и американских авторов. Это дает возможность студентам познакомиться со стилем научно-технической литературы различных источников. Часть отрывков оригинальной технической литературы представлена в виде диалогов. Орфография оригиналов сохранена. Этим объясняется расхождение в орфографии некоторых слов, в зависимости от того, взяты ли тексты из английской или американской технической литературы (в текстах из американских источников — aluminum, color, favor, neighboring vapor и т. д.; в текстах из английской технической литературы — aluminium, colour, favour, neighbouring, vapour и т. д.).

Пособие состоит из 9 частей и приложения. В приложение входят комментарии к текстам, список наиболее употребительных в технической литературе фразеологических оборотов, англо-русского словаря общетехнических и специальных терминов.

Первая часть учебника включает материал, посвященный развитию мировой науки и достижениям отечественных ученых в области науки и техники и деятельности выдающихся ученых. Тексты этой части могут быть использованы для бесед, сообщений, докладов на темы из разных областей науки и техники.

Вторая часть состоит из текстов по электричеству и магнетизму. В них освещаются вопросы о природе электричества, электрическом токе, электрических схемах, индуцированном электрическом токе, самоиндукции и т. д.

Третья, четвертая, пятая и шестая части пособия включают материал по атомной теории, полупроводникам, ядерной физике, радио и электронике, вычислительной технике, автоматике, электромашинам и измерительным приборам.

Седьмая часть («Texts for Class Work») включает материал для фронтальной работы в аудитории, тексты для чтения и перевода со словарем, для беспереводного понимания, обратного перевода, описания рисунков, приборов, пересказа и т. д.

Восьмая часть («Texts for Home Reading») состоит из текстов, предназначенных для самостоятельной работы студентов — внеаудиторного чтения, для составления аннотаций и рефератов. Эти тексты тематически и лексически связаны с темами основных разделов пособия. Тексты для самостоятельного чтения по тематике вполне пригодны для работы и на 4-м курсе.

Девятая часть («Exercises for Recapitulation») состоит из системы упражнений по грамматике на трудности, связанные с пониманием и переводом технических текстов.

Для того чтобы привить студентам навыки слитного чтения, перевода и беспереводного понимания специальной технической литературы на английском языке, а также развить разговорные навыки для ведения бесед по специальности, пособие снабжено большим количеством различных упражнений.

Так как это учебное пособие предназначено для работы со студентами, начиная со второго курса, авторы не ставили своей целью систематическое изложение курса фонетики, который проходят на первом курсе.

В пособии нет специальных фонетических упражнений, а даны упражнения на технику чтения трудных слов в тексте, чтение трудных буквосочетаний, упражнения на правильное ударение, слитное, беглое чтение, на фразовое ударение.

В систему лексических упражнений входят упражнения на подбор синонимов, антонимов, производных слов, а также упражнения на закрепление терминологии. Большое внимание уделено многозначности служебных слов, запоминанию словосочетаний, фразеологических оборотов, идиоматических выражений. Закреплению лексики служат также упражнения, направленные на развитие разговорных навыков (постановка вопросов, ответы на вопросы, заучивание диалогов, пересказы, переводы связных текстов с родного языка на английский и т. п.).

Для развития навыков аннотирования и реферирования к текстам разработана система упражнений: упражнения на составление аннотаций и рефератов на базе лексики текста, на перевод аннотаций с английского языка на родной язык и с родного на английский язык. Упражнения на составление планов к текстам и передачи содержания в соответствии с планами и темами, предлагаемыми в пособии, учат студентов последовательно излагать свои мысли и способствуют привлечению дополнительного материала для бесед.

С целью углубления, систематизации и практического применения грамматических явлений, наиболее часто встречающихся в научно-технической литературе, тексты снабжены грамматическими упражнениями. Особое внимание уделено таким грамматическим темам, как временные формы глагола; причастие и самостоятельный причастный оборот, инфинитив и инфинитивные конструкции; герундий и герундиальные комплексы; условные предложения и сослагательное наклонение; модальные глаголы с перфектным инфинитивом; эмфаза, бессоюзное подчинение, различные типы придаточных предложений и т. д.

Тексты подобраны по тематическому принципу с целью накопления, систематизации и закрепления лексического, фразеологического и грамматического материала. Но авторы предоставляют преподавателям, работающим по данному пособию, свободу выбора текстов и упражнений из любого раздела по своему усмотрению в соответствии со специальностью.

Что касается работы над материалом пособия, то можно порекомендовать следующее.

Работу над текстами следует начинать с упражнений на технику чтения, чтобы предупредить возможные ошибки при чтении. Лексические упражнения следует выполнять после работы над текстом. Грамматические упражнения могут выполняться до и после работы над текстом.

Работу над текстом можно организовать следующим образом. После упражнений на чтение («Reading Drills») следует перейти к внимательному чтению текста, уделяя особое внимание слитному чтению, фразовому ударению и произношению. В слабо подготовленных группах можно практиковать повторное чтение.

На всех занятиях следует уделять большое внимание технике перевода. Переводить можно весь текст или отдельные места его, трудные для перевода, но характерные для английской технической литературы, стремясь достичь технически грамотного перевода английского текста.

До и после чтения текста следует проводить тренировку на постановку вопросов и ответов, составление сообщения или диалога, связанного с определенной тематикой.

Для закрепления лексики и грамматики следует практиковать не только вышеуказанные методические приемы, но и перевод предложений с английского языка на родной и наоборот, уделяя особое внимание изучаемым грамматическим и лексическим явлениям.

В ряде текстов имеются рисунки и схемы, описание которых следует использовать на занятиях для более глубокого закрепления лексики и при самостоятельной работе студентов.

Можно надеяться, что овладение материалом пособия поможет студентам подготовиться к чтению и пониманию научной литературы на английском языке с целью извлечения полезной информации в той или иной области науки и техники.

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Part I

ON THE DEVELOPMENT OF SCIENCE

1. Soviet Science Serves Peace

The 20th century may be called the atomic, space or cybernetics age, the age of rapid engineering progress and of amazing scientific discoveries. Science is becoming a branch of economy serving as the foundation and source of economic and engineering progress.

The October Revolution exerted a tremendous influence on scientific progress. From the very outset V. I. Lenin gave great material and moral aid to Soviet science, the result being the Soviet Union's holding a prominent place in developing world science. The socialist system in this country has opened up unusual horizons for its progress on its road to the building of communism. Scientific research in our country is done on an enormous scale and along the entire broad front of modern science. The achievements of Soviet mathematics and physics have had a great effect upon the acceleration of scientific and engineering development.

The discovery of Vavilov-Cherenkov effect that is the radiation of an electron moving at a speed exceeding the phase speed of light in a proper medium was of outstanding importance for further developments. There is also the establishment of nuclear isometry in artificially radioactive elements by I. Kurchatov. Scientific research has been carried out recently in the synthesis and study of the properties of new elements. We have synthesizied and studied the heaviest 104th element which was called "Kurchatov" in honour of I. Kurchatov, outstanding Soviet physicist, one of the founders of Soviet nuclear engineering.

The high level of nuclear physics research made it possible for the Soviet Union to master in a brief period of time the energy of atomic nucleus and to become the first country to start using nuclear energy for peaceful purposes. The construction of nuclear reactors made it possible to organize in our country the production of radioactive isotops which have found a wide and varied application as a source of penetration radiation and as tracer atoms. In this way science has been given a powerful means for studying the complex processes taking place in the nature and used by technology. This method has been instrumental in obtaining exceptionally important results in a number of spheres of science within a relatively short time. The new sciences — biophysics and radio biology are developing rapidly. Radio physics, radio engineering and electronics may be safely said to have equally far reaching prospects for revolutionizing technology such as nuclear physics and atomic power engineering. The work of radio specialists carried out after the October Revolution very soon helped the Soviet Union to take the first place in the world in the construction of powerful radio transmitters.

Soviet scientists have contributed much to the physics of the plasma and to research into transistors. Studies of transistors had been started in the first years of Soviet power at the Leningrad Physical and Technical Institute on the initiative of A. F. Yoffe. On the basis of thermoelectric devices designed for obtaining electric power, refrigeration, thermostatic effects, etc. many practical results had been achieved, for instance, thermogenerators for radio receivers and radio stations were built as well as a number of devices for radio engineering, meteorology, biology and agriculture, and for domestic use.

Soviet scientists have built new sources of electromagnetic radiation — quantum generators, lasers and masers. Lasers and masers will in the near future cause a virtual revolution in the field of radio transmission, electronics and in new principles of computer design.

Electronic computers one of the wonders of the scientific engineering development have penetrated into production and into scientific research.

The rapid development of rocketry is known to be due to K. E. Tsiolkovsky, who laid the foundation of the theory of rocket motion, and to the search done by N. Ye. Zhukovsky and S. A. Chaplygin.

The USSR ushered in the era of man's penetration into outer space by launching the first artificial satellite (sputnik) of the Earth. Since then scientists have learned a great deal about cosmic influences on the Earth and discovered practical ways for using the sputniks for communications, meteorology and navigation.

The first man to penetrate into space was a Soviet man, a citizen of the Union of Soviet Socialist Republics, Yuri Alexeyevich Gagarin. This is an unprecedented victory of Man over elements, a tremendous achievement of science and technology, the triumph of human intelect. This event, of paramount historical significance, was the crowning point of a series of remarkable achievements of our scientists.

Foreseeing the great future in store for space flights[1] Academician Sergey Korolyov used to say that the performance by cosmonauts of various repair and construction work, including welding, would become not a fantasy but a necessity. And now it has happened.

The most characteristic feature of the Soviet science and technology is their being directed at peaceful applications and benefit for man, the construction of the first in the world atomic power station and the atomic icebreaker "Lenin" being one of the numerous examples.

EXERCISES

I. Read the following words:

branch, plant, fast, cast; society, science, variety; artificial, beneficial; brief, field, receive; initiative.

II. Arrange the following words in synonymical pairs:

aid, to be referred to as, uncommon, exploration, influence, to speed up, to apply, to achieve, to fulfil, fast, manmade, help, unusual, to be called, to use, to carry out, artificial, to accelerate, to reach, rapid, research, effect.

III. Write the words of the same stem, translate and memorise them:

to discover, progress, to serve, to result, to exceed, to apply, to mean, to process, equal, to produce, benefit, advantage, success, power, to found.

IV. Put questions to the text.

V. Be ready to speak on one of the topics given below:

1. The 20th century and science; 2. The influence of the Great October Socialist Revolution on scientific progress in the USSR; 3. The development of nuclear physics in our country; 4. The construction of nuclear reactors; 5. The achievements of Soviet science in radio engineering; 6. The research into transistors; 7. Lasers and masers; 8. The development of rocketry; 9. The Soviet Union and the era of cosmic research; 10. The most characteristic feature of Soviet science and engineering.

VI. Retell the text.

2. Discovery of Electromagnetism

Hans Oersted's childhood represented a minimal chance of either attaining greatness or serving his people so well, and over so long a span of life.

He was born in a small Danish town in August 14, 1777. His father was a village apothecary whose slender income made it difficult to feed his family, *let alone educating*[2] them in a town without even a school.

At 12 Hans was sufficiently mature to help his father in the apothecary shop, which helped to stimulate his interest in medicine and science.

In 1793 he decided to enter the University of Copenhagen and devoted himself to sciences of medicine, physics and astronomy.

He completed his training in pharmacy also, taking his degree with high honours in 1797, and in 1799 he was awarded the degree of doctor of philosophy along with a prize on an essay in medicine.

He proposed a fresh theory of alkalis which later was accepted in chemical practices.

Hans's student days were at the time when Europe was in a new intellectual ferment following the Revolution in America and a strong wave of intellectual awarness was sweeping the continent.

Oersted was stirred by the announcement about Volta's discovery of chemical electricity and he immediately applied the voltaic pile to experiments with acids and alkalis.

In 1803 Oersted applied for the University's chair in physics but was rejected. He continued experimenting and lecturing polishing the results of his experiments.

In the same year Oersted, simultaneously with Humphry Davy, discovered that acids increased the strength of a voltaic battery more than did salts.

In 1806 he became professor of physics at the Copenhagen University.

In 1814 Oersted took an active part in University political discussions. He supported the freedom of judgement as opposed to dogma. In 1819 he succeeded in producing light by creating an electric discharge in mercury vapor through which an electric current was made to flow.

The first direct event that led to the publication of Oersted's discovery of electromagnetism occurred during a lecture for advanced students in 1820. At this lecture Oersted happened to place the conducting wire over and parallel to a magnetic needle.

One says the experiment concerned the heating of some platinum wire by means of an electric current and that a compass needle happened by chance to be near and underneath the conducting wire. In any case Oersted observed the needle to swing strongly aside as though a magnet had been moved close to it. Using a more powerful battery and a large conductor Oersted repeated the experiment with startling results. After this he arrived at a set of conclusions which he published later in one of the most famous and rare bits of scientific literature. In this work he announced that an electric current in a conductor created a circular magnetic field around the conductor. Further, if the magnetic needle is brought into the field, surrounding the wire, it will set itself tangent to the circular field, continuing its tangential position if the needle is carried around the wire, pointing in one direction beneath the wire and in the opposite direction above it. The direction of the current being reversed in the conductor, the direction of the needle is similarly reversed from its former position. Various substances interposed between wire and needle had no effect on the latter. *Incredibly simple as this relationship seems to be*[3] it remained unobserved during two decades of investigation by many penetrating minds.

Oersted's discovery of electromagnetism literally electrified the entire scientific world.

EXERCISES

I. Read fluently:

a minimal chance, a village apothecary, for the University's chair, it has never been mentioned, as though a magnet had been moved, arriving at a set of conclusions.

II. Find in the text synonyms for:

to reach, enough, to make up one's mind, to finish, at once, at the same time; force, to show, to watch, to participate, similarity, significant, to take place, different, research, under, whole, to use.

III. Memorize the following pairs of antonyms:

beneath — above; former — latter; close — far; attraction — repulsion; increase — decrease; frequent — rare; more — less; to accept — to reject.

IV. Give derivatives of the following words and translate them:

to complete, to announce, to apply, to create, certain, to attract, to repel, to observe.

V. Give different meanings of the following words and illustrate them in sentences:

do, that, those, one, to apply, to make.

VI. Make up sentences using the following expressions:

either ... or, as though, along with, in any case, to take an active part.

VII. Translate and memorize the following expressions:

to complete a training in, to take a degree, to be stirred with, to be devoted to, as opposed to, to be contrary to, to arrive at a conclusion, incredibly simple.

VIII. Get ready to speak on one of the following topics:

1. Oersted's boyhood. 2. His education. 3. His life and scientific activity. 4. Oersted's participation in political discussions in the University.

IX. Answer the following questions:

1. Where did the thought of electromagnetism come to the mind of Oersted? 2. Where did Oersted place the conducting wire? 3. What was the experiment concerned with? 4. What did Oersted observe? 5. How did he repeat the experiment? 6. What conclusions did he arrive at? 7. What happened with the needle brought into a circular magnetic field? What happened to the needle if the current reversed its direction?

X. Be ready to speak about the discovery of electromagnetism and the significance of this great discovery

3. The Inventor of the Radio

A. S. Popov, the great Russian inventor, was born in 1859. By the time he graduated from the Petersburg University (1882) he had already possessed a broad knowledge of electrical theory as well as a wide experience in that field.

Woking both as scientist and teacher, he always carried on some practical work, solving many practical problems such as the introduction of electricity into the Navy and others. Popov was one of the first to pay attention to the works of Hertz who proved by experiments the existence of electromagnetic waves. After many experiments carried out together with his assistant Ribkin the device Popov constructed began receiving electromagnetic waves at a long distance. By means of his receiver Popov could detect the waves at a distance of some meters and then kilometers. The receiver recorded waves generated by lightning discharges. While experimenting the scientist found out that a free wire being connected to the receiver, the range of the latter increased. Thus he connected his first receiver to the first antenna.

On April 25, 1895, Alexander Popov demonstrated his device at the Russian Physico-Chemical Society. Having summarized the results of his experiments, Popov expressed his hope that the device, after being perfected, would make possible transmitting signals at a distance by means of rapid electrical oscillations. In summer 1895, Popov's invention was successfully tested and in the same year he attached to the device an apparatus previously used for recording telegrams over the wire telegraph. In the following year this receiver was used at the electric power station in Nizhny Novgorod for warning about approaching thunderstorm.

The great Russian inventor did not make any secret of his discovery, describing it in the press and making reports about it at the meetings of scientific societies. In the same year he demonstrated the transmissions of words over a wireless telegraph. This new demonstration proved to be of great importance.

In summer 1897, Popov successfully carried out his experiments at sea, having succeeded in effecting radio communication between the shore and the sea at a distance of 3 klm.

In this way the future wireless communication between the continents was being prepared. The year 1898 witnessed a new important invention made by Popov together with his assistants Ribkin and Troitsky, namely the reception of audible signals by means of a receiver. All these successful experiments having been completed, serious practical testing began. Popov's radio telegraph helped to save the battleship "General Admiral Apraksin".

Popov's work drew attention in many countries. The wireless telegraphy is the result of Popov's experiments, this fact having been acknowledged by different representatives of foreign science, engineering and industry. Popov was offered immense profits from commercial use of his invention in case he leaves Russia. But the Russian patriot refused the wealth offered to him, prefering to remain a true son of his fatherland "I am a Russian and I must give all my knowledge, all my work and all my achievements to my native land" were his words.

It is impossible to say that nobody in Russia understood and appreciated the great work carried out by Popov. On the contrary, the leading representatives of Russian science realized from the outset the significance of his inventions but the fate of the country was not in their hands. The tsarist government did nothing to provide the training of specialists for the newly born branch of science and engineering. *Neither was home production of devices for wireless telegraphy organized*[5] in Russia. Instead it was handed over to foreign companies.

Only the victory of the Great October Socialist Revolution could entirely alter the state of affairs. During the very first days of the October Revolution the new means of communication was used by Great Lenin in his struggle for the victory of Revolution.

DIALOGUE

A. I was told that you were a radio-amateur, aren't you?

B. Oh, yes. Radio is my hobby.

A. What branch of radio engineering are you interested in most of all?

B. In radio contsructing, certainly.

A. Is your interest in radio of purely theoretical nature or are you fond of designing too?

B. I'm an amateur-constructor. I've designed and constructed several radio sets and they are not bad, I believe.

A. Do you know who constructed the first radio set in the world?

B. Do you take me for such an ignorant person that you've put me such a question?

A. Sorry, it is only a joke. I think there are very few people who don't know about the pride of Russian science — A. S. Popov.

B. And the most remarkable thing about him is that he was not only a great outstanding scientist but a great patriot too.

A. Yes, of course. Though he was offered much money to go abroad, he utterly refused, saying that he was a Russian and all his knowledge and all his labour belonged to his people and his country.

B. Such high patriotism is very characteristic of Russian scientists.

A. Yes, there are many examples of this. It is great love for the native country and its people that promote the greatest achievements of our science and engineering.

B. You are quite right. Here lies the real reason of the progress our people have achieved.

EXERCISES

I. Give synonyms for the following words:

field, to carry on, to solve, device, to receive, to connect, importance, to complete, to draw the attention, technique, immense, to achieve, to appreciate, significance, to supply, entirely, to alter.

II. Form nouns from the following verbs and translate them:

to know, to invent, to graduate, to solve, to introduce, to prove, to exist, to assist, to detect, to record, to receive, to increase, to succeed, to warn, to describe, to transmit, to appear, to mean, to represent, to refuse, to signify, to produce, to depend (upon).

III. Form adjectives from the following words and translate them:

success, science, attention, to exist, to mean, distance, to suit, wire, importance, to invent, to complete, practice, frequency, to produce, to create, to depend, victory.

IV. Memorize the following expressions and groups of words:

as well as, to pay attention to, by means of, thus, the same, in this way, on the contrary, from the outset, to take place, at the age of, both... and, and so on.

V. Make up sentences, using the following word combinations:

as well as, by means of, in this way, on the contrary, to pay attention (to).

VI. Give different meanings of: *very, as, for.* Illustrate their use in sentences.

VII. Learn the parts of A and B in the dialogue.

VIII. Choose one of the topics below and prepare to talk about it:

1. A. S. Popov and his inventions. 2. The conditions of life of Russian scientists under tsarism. 3. The development of radio in our country after the Great October Socialist Revolution.

IX. Retell the text according to the topics given above.

4. From Mendeleyev to Mendelevium

Dmitry Ivanovich Mendeleyev is known to be the creator of a periodic classification of the elements based on their atomic weights and chemical properties. He is probably well known in other countries as he is in the land of his birth. The Periodic Law has crossed national boundaries and has become the property of all nations, just like the works of Newton, Copernicus, Lomonosov, Lavoisier, Darvin, Pavlov, Lobachevsky and Einstein.

When speaking about the Periodic Law, we cannot fail to stress its tremendous philosophical importance. It reflects the dialectical interdependence between the structure of atoms and the properties of elements, i. e., the transfer of quantity into a new quality. As the charges of the atomic nuclei grow and their electron shells alter, we notice changes in the physical and chemical properties of the elements. Like all major discoveries the Periodic Law has a prehistory of its own. Before Mendeleyev, several chemists made attempts to find the laws governing elements and systematize them. But they based their research on erroneous concepts about the main things which determine the properties of elements, and so failed to build up a single comprehensive system.

It was only after gallium, scandium and germanium were discovered, and after the properties of a number of elements predicted by Mendeleyev were confirmed, that Mendeleyev at long last was objectively recognized as the founder of the Periodic Law.

In the space of a few years[6], Mendeleyev was elected an honorary member of the American, Irish, Rome, Berlin, Belgian, Danish, Czech, Kraków and other academies of sciences, a member of London and Edinburgh Royal societies and an honorary doctor of Cambridge, Oxford and other universities. Altogether 150 scientific and educational institutions in various countries elected him as an honorary member. In the Soviet Union, the All-Union Chemical Society, a number of higher and secondary schools and some industrial plants have been named after Mendeleyev. The USSR Academy of Sciences and the Mendeleyev Society awarded the Mendeleyev prize and the Mendeleyev gold medal for outstanding research work.

The significance of the now famous table of Mendeleyev lay in his bold predictions that deficiencies or gaps in his system were due to gross errors in the previous measurements of atomic weights or simply to the fact that certain elements had not yet been discovered. His specific and successful prediction of the existence of three elements, gallium, scandium, and germanium, resulted in general acceptance of his periodic classification before the end of the nineteenth century.

Later on the element 101 having been discovered, American scientists called it "mendelevium" to honor Mendeleyev's name.

Soviet scientists are hard at work trying to discover new elements.

The rapid development of science since the time of Mendeleyev has caused many widely accepted science theories to become obsolete. Yet Mendeleyev's Periodic System continues to form the basis for the most complex research to-day.

EXERCISES

I. Read fluently:

the creator of a periodic classification of the elements, the land of his birth, the property of all nations, the transfer of quantity into a new quality, prehistory of its own, in the space of a few years, before the end of the nineteenth century.

II. Give synonyms for:

probably, boundary, to become, importance, tremendous, i. e., quantity, alter, major, main, number, concept, confirm, honor, recognize, predict, certain, rapid, to continue.

III. Give antonyms for:

major, efficiency, success, slow, result in, obsolete, complex, accept, charge.

IV. Give derivatives of:

create, proper, class, fail, depend, cover, attempt, govern, system, determine, number, fame.

V. Make up sentences using the following expressions:

as well, a number of, to be named after, to award a prize, to be due to, later on, to be hard at work.

VI. Choose one of the topics below and be ready to speak of:

1. D. I. Mendeleyev — the creator of the Periodic Law. 2. The prehistory of the Periodic Law. 3. The significance of Mendeleyev's table of elements.

VII. Put questions to the text.

5. Kurchatov — Scientist and Communist

Physics, above all atomic physics, *is advancing with sevenleague strides*[7]. With joy and pride we see that the genius of the Soviet people is mastering the atom's secrets.

Among the distinguished atomic scientists the first place belongs by right to Academician Igor Kurchatov — scientist and communist. He had the honour of being the senior scientific director responsible for the development of atomic industry and atomic technique in our country. He laid the foundation of the atomic might of the land of Soviets.

As far back as the early thirties[8], atomic research was being successfully conducted in the Soviet Union. Soviet nuclear physics was in need of powerful sources of fast particles capable of inducing a nuclear reaction. This problem was being solved by a group of young research workers with I. Kurchatov at the head, his optimism, vigour and faith in success inspiring their work.

Having completed a series of experiments, I.Kurchatov launched Europe's first cyclotron at the Radio Institute. Shortly before the outbreak of the Great Patriotic War the biggest in Europe cyclotron was built at the Leningrad Physico-Technical Institute.

I. Kurchatov together with B. Kurchatov, L. Mysovsky and L. Rusinov made a major discovery in nuclear physics — the isomerism of artificial radioactive nuclei.

I. Kurchatov knew that the neutron was the key to splitting the atom. This is why he put all his efforts into neutron research. The main, the most important objective to release the power of atomic nucleus was still ahead of him. The idea of releasing gigantic resources of atomic energy haunted I. Kurchatov. But World War II broke out and all research programs had to be suspended.

Academician Anatoly Alexandrov having discovered a way of protecting ships from mines, I. Kurchatov joined in and began to work for the Navy. In the Baltic and then at Sevastopol under enemy-fire the Soviet scientists-patriots were engaged in anti-mine treatment on men-of-war. *Many a time*[9] they risked their lives during enemy air raids but nothing could stop them.

Research into uranium fission having been resumed at the decision of the Party and the Government, Kurchatov left the front line and a special laboratory headed by Kurchatov commenced operations in Moscow. The war was drawing to a close and I. Kurchatov was already dreaming about using the atom for peace. "The aim is atoms for peace" Kurchatov used to say.

On June 27, 1954, the first atomic power plant in the world with a capacity of 5000 kw was put into operation near Moscow. This power generating installation based on the uranium-graphite reactor was the favourite creation of I. Kurchatov.

Like other Soviet scientists I. Kurchatov was carried away by another great idea — to master controlled thermonuclear reactions. Kurchatov was over 50 when with youthful vigour he threw himself heart and soul into research into controlled fusion.

In 1956 I. Kurchatov visited Britain. At Harwell he presented a report on Soviet research into controlled fusion. By his report Kurchatov once again demonstrated the will of all Soviet scientists for peace, for friendship and understanding with other scientists in settling fundamental problems of contemporary science.

Kurchatov's mind, his will-power, his experience and his knowledge as a scientist and communist have become immortalized in the world's first atomic power plant, in the magnificent problem of atomic power engineering, in the first atom-driven icebreaker in the world, "the Lenin", in the Dubna Institute, in numerous atomic reactors built and directed in different parts of the Soviet Union and other countries — in the countries of the socialist camp, in the broad development of thermonuclear research in our contry.

EXERCISES

I. Read the following words:

league, guard, guest; torque, unique, technique, guarantee, research, fusion, fission.

II. Find in the text synonyms for the following words. Illustrate their use in sentences:

famous, power, mighty, to investigate, chief, significant, to cease, purpose, man-made, various.

III. Form derivatives from the following words and translate them:

1) **nouns from:** to research, to induce, to solve, to complete, to break out, to discover, to protect, to treat, to resume, to know, to differ, to settle, to inspire;

2) **adjectives from:** pride, science, honour, to found, success, to complete, art, favour, youth, to differ.

IV. Make up sentences, using the following word combinations:

as far back as..., to solve a problem, to lay the foundation, to put into operation, at the head.

V. Be prepared to answer the following questions:

1. Why does the first place among the distinguished atomic scientists belong to I. Kurchatov? 2. When was atomic research begun

in the Soviet Union? 3. By whom has the problem of finding powerful sources of fast particles capable of inducing a nuclear reaction been solved? 4. When and where was the biggest cyclotron in Europe built? 5. Why did Kurchatov put all his efforts into neutron research? 6. Why was the research program put off? 7. What was Kurchatov's favourite creation? 8. What other great idea attracted Kurchatov's attention? 9. What did his report at Harwell demonstrate? 10. What immortalized creations of Kurchatov's genius do you know?

VI. Translate into English:

Атомная физика начала развиваться очень быстро в тридцатых годах этого столетия. Одним из выдающихся ученых в этой области был И. Курчатов. Все свои знания и энергию он посвятил решению серьезнейших научных проблем. Он создал свою школу и возглавлял ряд исследовательских институтов. Курчатов — ученый и патриот — внес огромный вклад в дело защиты нашей Родины. Благодаря его работам, еще в 1954 году была введена в эксплуатацию первая в мире атомная электростанция. Много усилий И. Курчатов посвятил использованию атомной энергии в мирных целях.

VII. Make an information on one of the topics below:

1. The advance of atomic physics in our country. 2. The role of I. Kurchatov in the development of atomic physics. 3. I. Kurchatov's work during World War II.

6. Semiconductors — New Branch of Science

The successes of physics of semiconductors attained in our country are linked with the name of the famous Soviet scientist — Academician A. F. Yoffe. He began to concentrate on physics of semiconductors in the early thirties. He had a wide range of scientific interests. His research involved light waves, the mechanism of plastic deformation, the photoelectric effect.

At that time little importance had been attached to the ability of semiconductors to absorb heat and produce electricity since the efficiency was extremely low. And then Academician Yoffe declared that the research into semiconductors had points of theoretical interest and held out great promise for commercial development. This sounded quite fantastic at that time.

It did not take the scientist too much time to prove his point. Semiconducting elements with an improved efficiency were developed shortly before World War II.

Yoffe drew into the research of semiconducting materials a number of young research workers, his wife being his closest assistant and associate.

The data compiled by Yoffe as a result of his fundamental research enabled him to formulate a systematic theory of semiconductors which paved the way for their large scale commercial utilization.

The formerly insignificant efficiency of the semiconductors began to climb and promised to rise up to 25 per cent. Semiconductors have found their way to radio-receivers and television sets, they became essential in measuring techniques thanks to their being extraordinarily sensitive to light, temperature and atmospheric humidity. However, all this was only the beginning in this new branch of physics. *Yoffe was after problems*[10] that were more complex and of greater value.

The last thing one could call Yoffe was an armchair scientist[11]. He was against experiment for the sake of experiment. He believed that research had to be organized so that physics would provide the scientific foundation for the technology of socialism.

In studying the theory of semiconductors Yoffe had in mind the direct conversion of solar energy into electricity. He thought it abnormal that of the energy so generously sent by the sun only a small fraction was used by man, only a quarter of one per cent. And even making use of this fraction involved tremendous difficulties: the mining of coal, the construction of turbines and other equipment. Scientists working in this field were looking for a way of converting solar energy and making it serve people directly. Yoffe perceived such a possibility in semiconducting thermal elements in which an electric current is induced by ordinary light. A solar battery 100 km. long could provide enough power to meet the world's demands.

A long series of experiments and preliminary theoretical studies enabled the scientists to find thermo-electric systems with an extraordinary high efficiency, and develop a kind of a miniature power plant. Electric stations of this type are now being made use of. Solar batteries are successfully operating on board the Soviet spaceships. They are well known in the northern areas of our country and in the Antarctic, in India and Indonesia. In the absence of the usual electric transmission lines they serve as power sources for local telephone exchanges and transmitters.

Much of what was discovered and proved by Yoffe has now become part of ABC of physics. The great future of semiconductors is a generally recognized fact. Many industries in the Soviet Union are based on semiconducting elements. Photoelectric elements controlling the operation of rolling mills are used as quality checks. *A new branch of industry — helio engineering — has come into being*[12]. Semiconductors are widely used in practical farming.

Yoffe noticed that semiconducting elements may serve equally well as sources of heat and cold. Semiconductor refrigerators have been developed. In our age, semiconductors mark a new stage in the history of physics, a stage linked with the name of Academician Yoffe who was posthumously awarded the Lenin Prize for theoretical and experimental research into the properties of semiconductors and for evolving the theory of thermo-electric generators.

DIALOGUE

A group of students are having practical training in the laboratory of semiconductors. The demonstrator asks the students about the properties and uses of semiconducting materials.

D e m o n s t r a t o r: Comrade Ivanov! Can you tell me what a semiconductor is?

I v o n o v: Certainly, I can. A semiconductor is a substance that conducts electricity with the help of electrons, but less effectively than metals do, yet much better than insulators. Hence the name — "Semiconductors".

D e m o n s t r a t o r: Name some semiconductors, please.

S t u d e n t: These are all the minerals, many chemical elements and metals.

D e m o n s t r a t o r: And what about chemical and organic compounds?

S t u d e n t: Many chemical and organic compounds are semiconductors too.

D e m o n s t r a t o r: What properties do minerals and crystals possess?

S t u d e n t: As far as I know their conductivity increases with heating and falls with cooling.

D e m o n s t r a t o r: Is it the only property you know of?

S t u d e n t: Sorry, I've forgotten to mention their sensitivity to light too. For the chemical properties of germanium may change under the action of light.

D e m o n s t r a t o r: And radiation as well, is it not so?

S t u d e n t: Of course, it is.

D e m o n s t r a t o r: Can you tell me anything about the application of semiconductors?

S t u d e n t: Semiconductors play an important part in very many fields of industry and engineering. They are so widely used now that it is difficult to mention all their applications.

D e m o n s t r a t o r: Still name some of them, please!

S t u d e n t: Semiconductors are used for transforming light and heat energy into electrical energy. They can generate heat or cold from electricity. Besides, semiconductors are used for reproduction of sounds, for transmission of signals, automatic control, for switching on engines.

D e m o n s t r a t o r: That'll do.

EXERCISES

I. Read the following words:

a) with the stress on the first syllable: interest, area, promise, formulate, organise, generous, solar, ordinary, operate, local, element;

b) with the stress on the second syllable: success, efficiency, declare, develop, research, assosiate, enable, tremendous, preliminary, award, absorb, improve;

c) with the stress on the last syllable but one: scientific, electric, fantastic, fundamental.

II. Pick up synonymical pairs out of the following list of words:

to attain, investigation, since, to convert, to utilize, huge, sufficient, to demand, common, to regulate, ordinary, to achieve, research, significance, as, branch, to observe, to transform, to make use of, tremendous, enough, to require, usual, to control.

III. Pick up antonymical pairs out of the following list of words:

early, narrow, low, to rise up, complex, to send, to find, absence, late, wide, high, to lower, to receive, to look for, simple, presence.

IV. Read the dialogue. Learn the parts of the demonstrator and the student.

V. Put questions to the text.

VI. Choose one of the topics below and prepare to talk about it:

1. Academician A. F. Yoffe and his scientific activity. 2. The theory of semiconductors at that time. 3. Academician Yoffe's views upon scientific research . 4. The problem of direct conversion of solar energy into electricity. 5. The use of semiconductors nowadays.

7. Discovery of Natural Radioactivity

The French scientist Antoine-Henry Becquerel (1852—1908), while experimenting in 1896 with fluorescence produced by X rays, discovered that uranium salts emit uncessingly a type of radiation that is able to blacken photographic plates, this phenomenon being called radioactivity. The husband-and-wife team of Pierre Curie (1859—1906) and Marie Sclodowska-Curie (1867—1934) continued these investigations and discovered much stronger radioactive elements — radium and polonium, the latter being named after Marie Sclodowska-Curie's native country, Poland.

Investigations of the properties of radioactivity showed the strength of the radiation to be independent of chemical combination and of any external physical influences such as temperature, pressure, exposure to light, and X-ray or cathode-ray bombardment. Thus, radioactivity became recognized as a property of the element itself, or more properly, of the nucleus of the atom.

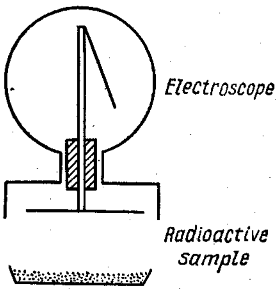

Fig. 1

It was soon found that the gold-leaf electroscope was more sensitive for measuring radioactivity than the photographic plate. This device, adapted for the study of radioactivity, is shown in the accompanying figure. Here the supporting rod for the thin metal foil projects through an insulating collar in the bottom of the metal chamber and terminates in a metal plate. The shell of the electroscope surrounds this plate, and the radioactive material to be tested is placed at a known distance below the plate. The radioactive emissions ionize the air within the instrument and the electroscope, originally charged, is observed to discharge.

With the electroscope it was discovered that three kinds of radiation are given off, but that not every radioactive material emits all three. The strongest radiation, named alpha rays, was found to give measurable effects up to sample-to-electroscope distances in air of one to three inches, depending upon the material under test. At slightly greater distances the discharge rate decreased markedly; the results suggested specific ranges in air for these rays. With the sample located beyond the terminal range of the alpha rays, a weaker emanation, called beta radiation, was still observed. The effect of these rays was lessened by interposing metal foils a millimeter or two thick between the sample and the electroscope. A third type of radiation, named gamma radiation, was then measured; it was much weaker than the other two but very penetrating, and could only be stopped by absorption in several centimeters of lead.

Experiments conducted in a uniform magnetic field established the following facts: alpha particles carry a positive charge twice as large as the negative charge on the electron and have a mass about four times that of the hydrogen atom; beta particles are negatively charged with exactly the charge of the electron but have a mass which may be many times that of the electron. Diffraction experiments show gamma rays to be electromagnetic waves having wavelengths shorter even than X rays.

The mass and charge found for alpha particles suggested that these might be helium nuclei — that is, helium atoms with the two valence electrons removed.

EXERCISES

I. Find in the text synonyms for the following words and memorize them:

to name, to go on, to indicate, force, to place, initially, to watch, some, accurately, speed.

II. Change the following adjectives and nouns into verbs, adding the suffix *-en*; translate the verbs:

black, dark, wide, weak, strength, length.

III. Be ready to answer the following questions:

1. When did Becquerel discover radioactivity? 2. What phenomenon is called radioactivity? 3. Who continued these investigations and what did they discover? 4. What is the strength of the radiation dependent of? 5. How many kinds of radiations were discovered with the electroscope? 6. Does every radioactive material emit all kinds of radiations? 7. What do you know about alpha rays radiation? 8. What is referred to as beta radiation? 9. What do you know about gamma radiation? 10. What facts did experiments conducted in a uniform magnetic field establish? 11. What did the mass and charge found for alpha particles suggest?

IV. Describe the device adapted for the study of radioactivity (see Fig. 1 on p. 28).

V. Make a plan of the text.

VI. Retell the text according to your own plan.

8. S. P. Korolyov

The name of the outstanding Soviet scientist academician Sergey Pavlovich Korolyov will forever be linked with the dawn of man's exploration of space. His professional carrier started by designing a glider. When he was 24 he graduated from higher technical school, became a glider designer and finished a flying school. He read K. Tsiolkovsky's works and was captivated by the ideas in them. S. Korolyov devoted to rocket-engineering all his great talent and scientific insight based on a deep theoretical knowledge associated with practice. His hobby — designing gliders helped him very much in this. S. Korolyov installed the first jet engine of unusual construction on a tailless glider designed by B. Charanovsky. He soon designed another more durable glider which was to be the beginning of the rocket plane. He tested the engine himself which meant taking great risks since breakdowns did happen.

Years passed and S. Korolyov's rare talents developed and matured.

Then it was on October 4, 1957 that a rocket system evolved under his guidance put the first sputnik into orbit round the Earth, all the subsequent stages in space exploration going on with his direct participation.

Then came the morning of April 12, 1961. The first manned spaceflight was a worthy consummation of all the work on space conquest that had preceded it.

Academician S. Korolyov is known to have been a great scientist and designer. Those who worked with him say that it was always interesting to listen to him even though he mostly spoke in engineering formulae.

His amazingly dynamic thought thrilled, even charmed his audience and the iron logics of his arguments sounded utterly convincing.

EXERCISES

I. Find in the text synonyms for:

always, prominent, to connect, investigation, to begin, to end, to assist, as, technique, to take part, to take place, to work out.

II. Write all the words you know of the same stem:

science, to explore, to know, to install, to use, to mean, to guide, man, to think, to participate.

III. Make up adjectives adding the suffixes *-ful, -less and/or -able* and translate these words:

use, help, power, loss, home, tail, worth; value, consider, appreciate, compare, reason; obtain, avail.

IV. Make a report on one of the following topics:

1. Tsiolkovsky — the founder of the theory of rocket-engineering. 2. The first in the world man-made Earth satellites. 3. The first

flight into cosmic space. 4. The first automatic space station. 5. The flight of the spaceships "Soyuz".

V. Put questions to the text.

VI. Be ready to speak about:

Academician S. Korolyov — the outstanding scientist, theoretician and designer in rocket engineering.

9. The Soyuz-Apollo Flight

The first joint flight of the Soviet and American spaceships "Soyuz" and "Apollo" that took place on July 15, 1975 is of tremendous importance for world scientific progress. The flight was the culmination of the truly gigantic work done to realize this ASTP* project. The specialists had to construct compatible ships in geographically remote countries. Many systems of the ships were modernized to ensure intercommunication, rendevous and other kinds of interaction. The docking assembly that couples the ships and produces the airtight tunnel for crew transfers had to be built anew. The main task of the ASTP was to develop entirely new compatible means of rendevous and docking of the future spaceships and stations, and to perform rescue operations in space, if necessary.

Together with American specialists Soviet experts went through all the stages of this extraordinary flight. The joint flight fully confirmed that.

All the joint experiments carried out during this flight related to important trends in space science. The experiment "Artificial Solar Eclipse" opens new scientific horizons. In space flights the part of the corona spectrum that does not reach the earth and is absorbed by the terrestrial atmosphere completely could be studied by man.

The experiment "Microbial Exchange" and others dealt with the problem of man's working capacity in space and the effect of radiation on it. The "Multipurpose Furnace" experiment is the first step in the development of space engineering. It is now clear that materials of exceptionally high quality, vital for modern industry can be made in a state of weightlessness. The scientific value of these experiments is enormous.

Many barriers had to be overcome — both technical and language. Therefore most of our specialists took up the study

* ASTP — Apollo-Soyuz Test Project.

of the English language. Many of them achieved very good results. The importance of that for solving the problems involved in carrying out the flight is hard to overestimate.

The significance of the ASTP is not confined to technical achievements only. It has shown that countries with different social systems can cooperate to mutual advantage.

This flight has become a symbol of peaceful coexistence of all the peoples on the Earth and a symbol of international cooperation in all spheres of activity. This cooperation has humane aims — to strengthen world peace.

EXERCISES

I. Read the following words:

interconnection, interaction, interrelation, intercommunication, interchange, interchangeable; to overcome, to overestimate, to overload, to overlook; to undergo, to underestimate, to undermine; to superheat, to superimpose.

II. Translate the following words and memorize them:

cooperate, cooperation; exist, existence, coexistence; assemble, assembly; compatible, compatibility, incompatibility; communication, intercommunication; act, action, interaction; weight, weightless, weightlessness; estimate, overestimate; to mean, means, meaning; fly, flier, flight.

III. Find in the text synonyms for:

significance, distant, to connect, chief, completely, to limit, purpose, to fulfil, to have to do with.

IV. Answer the following questions:

1. When did the Soyuz-Apollo flight take place? 2. What did the specialists have to do in order to realize the ASTP? 3. What assembly was built anew? 4. What was the main task of the flight? 5. What kinds of experiments were carried out? 6. What did the experiments show? 7. What was studied during the "Artificial Solar Eclipse" experiment? 8. Is the significance of the ASTP confined to technical achievements only? 9. What kind of symbol has this flight become? 10. What did this wonderful flight show?

V. Make up the plan of the text.

VI. Retell the text according to your plan.

VII. Translate into English:

Космический полет «Союз-Аполлон» имеет огромное научное и техническое значение. Трудности, которые пришлось преодолеть экипажам обоих кораблей, огромны. Отличная подготовка, знания, личное мужество и совместные усилия обоих экипажей дали чудесные результаты. Этот полет показал возможность взаимного сотрудничества всех народов на земле, независимо от социального строя разных стран.

10. Discovery of the Generation of Radio Waves in Molecular Beams

Alexander Prokhorov, a graduate of the Leningrad University, appeared in the Institute of Physics of the USSR Academy of Sciences in 1939. He wanted to work in the field of radio physics and joined the investigations of radio waves propagations.

The main subject under study at that time was the general theory of oscillations. In great demand were highly skilled mathematicians and physicists. Prokhorov could fully meet those requirements. So he found himself in one of the most advanced schools of modern physics. Soon the Great Patriotic War broke out. He was badly wounded. Having been demobbed, he took a post-graduate course and defended his thesis on the basis of his theoretical and experimental researches.

At that time a young man came to work at the Institute of Physics. It was Nikolai Basov who later became one of the prominent Soviet scientists. Both Prokhorov and Basov were interested in radio spectroscopy. Later Basov defended his thesis based on his investigations.

At approximately the same time a young physicist Charles Towns by name was working in the same field of physics at the Columbia University of New York. Quantum physics came into being in 1954, when Prokhorov and Basov in the USSR and Charles Towns in New York simultaneously and independently discovered the generation of radio waves in molecular beams. They used a device of quite a new type, a molecular generator or "maser" as it was called in New York. The word "maser" consists of the first letters of an English phrase describing the principle of operation of the device — Microwave Amplification by Stimulated Emission of Radiation.

Together with quantum radio physics the science of quantum radio electronics came into existence.

Atoms in various combinations form all the diversity of the world created by man and nature. Thus, simple chromium oxide, having got into a colourless corundum, turns the latter into a beautiful ruby, In a colourless beryllium, chromium oxide is transformed into an emerald.

Both the Soviet and American molecular generators are genetically alike, but they have some differences. The heart of these two devices is the volumetric generator. Here forced emission and feedback are combined.

In Moscow as well as in New York ammonia was the working body. Its molecules have the most intensive spectral lines in the centimeter wave range.

Basov and Prokhorov worked much to perfect the molecular generator. Their scientific achievements are highly appreciated all over the world. They are Nobel Prize winners. At present these two outstanding scientists are working at the application of powerful maser pulses for thermonuclear reactions. They have founded the Soviet school of quantum radio physics widely recognized all the world over. Along with their tremendous scientific activity these scientists are carrying on great social work and make a great contribution to the triumph of Communism in our country.

EXERCISES

I. Read the following words with the proper stress:

thesis, basis, centimeter, colourless, diversity, intensive, molecular, appreciate, mathematician, academician, experimental, independently, recognize, outstanding, alike, simultaneous.

II. Read fluently:

the general theory of oscillations, one of the most advanced schools, experimental investigations, one of his researches, in the same field of science, at approximately the same time, in the same field of physics, of quite a new type, the science of quantum radio electronics, all the diversity of the world.

III. Find in the text synonyms for:

prominent, requirement, investigation, at the same time, mighty.

IV. Answer the following questions:

1. In what branch of science did Prokhorov want to work? 2. What was the main subject studied at that time? 3. When did Basov come to the Institute of Physics? 4. What was he interested in? 5. Where and when did Charles Towns work? 6. When did quantum physics come into being? 7. What was the result of their work? 8. What is the maser? 9. What do you know about the volumetric generator? 10. What property of ammonia do you know?

V. Speak about Prokhorov's and Basov's activities.

VI. Make short reports on the following topics:

1. The discovery of the Generation of Radio Waves in Molecular Beams. 2. Quantum mechanics, its application in modern physics. 3. The maser, the principle of its operation.

Part II

ELECTRICITY AND MAGNETISM

11. Nature of Electricity

DIALOGUE

A. When was the first recorded observation on electricity made?

B. As much as I know it was made by the Greek philosopher Thales.

A. What did he state, I wonder?

B. Don't you know? He stated that a piece of amber rubbed with fur attracted light objects such as feathers and bits of straw. Did he make any experiments?

A. No, as far as it is known Thales liked to speculate but he did not experiment systematically. Twenty-two centuries elapsed before there was any progress.

B. Oh, it was just about the time that Galileo discovered the laws of the pendulum and accelerated bodies. So it was at the time when the study of magnetism and of electrical phenomena began.

A. How was it found out that some substances could be "electrified"?

B. It is a well-known fact that having been rubbed many substances behave like amber does.

A. Can only similar substances become electrified or acquire electrical charges, being touched together and then separated?

B. No. Later on it was discovered that any two dissimilar substances could be electrified. As a matter of fact rubbing is not essential. It merely forces the two substances into close contact.

A. When was the modern concept of the nature of electricity arrived at?

B. During the past century the idea of the nature of electricity was completely revolutionized.

A. Yes, I know it quite well. Hitherto the atom has been regarded as the ultimate subdivision of matter. Today the atom is regarded as an electrical system.

B. Oh, now I want to examine you a little. What do you know about the nucleus, the proton and the electron?

A. I don't mind. In the electrical system there is a nucleus containing positively charged particles. These particles are called protons. The nucleus is surrounded by lighter negatively charged units — electrons. So, the most essential constituent of matter is made up of electrically charged particles.

B. I see that you have an idea about this but you did not tell me when matter is neutral.

A. But everybody knows that matter having equal amounts of both charges is neutral — that it produces no electrical effects.

B. And what happens if the number of negative charges is unlike the number of positive ones?

A. Well, then matter will produce electrical effects. Having lost some of its electrons, the atom has a positive charge; having an excess of electrons — it has a negative charge.

B. So, as a matter of fact you do know the material.

EXERCISES

I. Read the following words:

half, fasten, often; unit, 'measure, 'infinite, 'ultimate, 'hitherto, to con'tribute, comp'lete, cons'tituent, to revo'lutionize, indis'criminate.

II. Find in the text synonyms for the following words:

indeed, fully, to be composed of, to demand, quantity, substance, to cause, only, to consider.

III. Give derivatives from the following words and translate them:

to measure, to know, to divide, unit, to consider, to require, equal, to produce, excess, number, like.

IV. Give Russian equivalents for:

in other words, hitherto, in fact, as a matter of fact, with regard to, regardless of, to be in excess of.

V. Translate the following sentences, paying attention to the meaning of the expressions in italics:

1. In *dealing with* direct currents any potential difference *in excess of* five volts should be considered unsafe. 2. Tubes with rating *in excess of* about 1 kw require special means of cooling. 3. The number of protons in the nucleus *in excess of* the number of electrons in the nucleus is called the atomic number and determines what the element is. 4. *Regardless of* the external shape of the crystal, the internal arrangement of the atom is the same. 5. The difference of potential between the terminals of every dry cell, *regardless of* size, is approximately 1.5 volts. 6. There are only three differ-

ent types of ionic reactions if we classify them *with regard to* cause. 7. As a matter of fact, most of our knowledge of the nature of atoms has come from the work of physicists. 8. *As a matter of fact*, the methods used in measuring activities depend upon wellknown equilibrium laws.

VI. State the functions of the words ending in -ed.

1. V. V. Petrov *discovered* the permanent flame setting up between two char-coals under current. 2. The pheomenon *discovered* by V. V. Petrov was of greatest importance for the development of the science of electricity. 3. Many interesting phenomena were *discovered* by him, which *contributed* a great deal to the development of science and technique. 4. In order to observe electrification by friction we *rubbed* two dissimilar substances. 5. Two dissimilar substances *rubbed* together become *electrified*. 6. *Rubbed* together the two dissimilar substances have become *electrified*. 7. When an electric charge is in motion it is *referred* to as an electric current. 8. The voltage *referred* to in the case under consideration was extremely high. 9. The laboratory just *referred* to was *provided* with the most modern measuring devices. 10. There are many laboratories *provided* with the modern equipment of the best Soviet make. 11. The experimenter will be able to carry out numerous tests *provided* he is given all necessary instruments.

VII. State the function of the Participles in the following sentences and translate these sentences:

1. The ampere is the practical unit *representing* the rate of flow of electricity. 2. An ammeter is really an electron-flow-*indicating* machine. 3. The ampere is simply a measure of the number of electrons *passing* a given point in a second of time. 4. The *magnetizing* effect of current depends on the strength of the current and on the number of turns through which the current flows. 5. In the Figure *given* below the currents is *flowing* in the opposite direction. 6. *Placing* a magnetic material in the field of another magnet, we can magnetize it to a certain degree. 7. When *flowing* through a conductor the *alternating* current reverses its direction at regular intervals. 8. While *magnetizing* the magnetic material, we stroke it with a permanent magnet. 9. A large amount of different rubber components are available which have different characteristics, *depending* upon the service conditions for which they have been developed. 10. Faraday found that if a metallic circuit, say a copper ring, is placed in the neighbourhood of magnets or of conductors *conveying* electric currents in such a position that a magnetic flux passes through the ring or circuit, the lines of magnetic flux *being linked* through it, and if a total amount of magnetic flux *passing* through the ring is altered or in any way changed, then under these circumstances an electromotive force is set up in the ring or circuit. 11. The force *driving* round the armature of the meter is proportional to the product of the strength of two currents, one of which is the current going into the circuit *being measured*, and the other of which is proportional to the terminal voltage of the circuit *being metered*.

VIII. State the functions of the Past Participles in the following sentences. Translate these sentences:

1. When a glass rod *rubbed* with silk is *brought* close to a bit of paper, there is attraction. 2. When *used* with an input resistance of

10^5 ohms, a current amplification of 250,000 may be obtained. 3. When two different substances are *rubbed* together and then separated, it is *found* that both are electrified. 4. When the *electrified* end of a similarly *charged* rod is *brought* close by, the *suspended* rod turns away, showing repulsion. 5. A *charged* sphere, whether hollow or solid, when *isolated* so as to be uninfluenced by its surroundings, will show the same separation of the electroscope leaves when *tested* with a proof plane at all points on the outer surface. 6. If *lined* up parallel to each other and to the magnetizing field, the small N and S poles of elementary magnets are adjacent to each other and cancel each other's effect on external objects.

IX. State the forms and functions of the Participles in the following sentences. Translate the sentences:

1. *Having made* many tests, the experimenter got interesting results. 2. *Having been tested* under unfavourable conditions the machine was successfully put into operation. 3. *Having finished* the research, the scientist made a thorough analysis of the data obtained. 4. *Having been insulated* with a new kind of insulating material the cable was tested under different conditions. 5. *Having used* all the data available the scientist suggested a new interesting method of analysis. 6. *Having analysed* the properties of the substance the experimenter arrived at new valuable conclusions. 7. *Having carried* on many experiments and tests on luminescence V. V. Petrov published many articles on this subject. 8. *Having lost* some of its electrons the atom has a positive charge. 9. *Having been rubbed* many substances become electrified. 10. The atom has a negative charge, *having acquired* an excess of electrons.

X. Be ready to answer the following questions:

1. When were the ideas of the nature of matter and electricity revolutionized? 2. How was the atom regarded up to the second half of the past century? 3. How is the atom regarded to-day? 4. What is matter now considered to be made up of? 5. What matter is neutral? 6. When does matter produce electrical effects? 7. When has the atom a positive charge? 8. When has the atom a negative charge?

XI. Learn the dialogue.

12. Electric Current

DIALOGUE

D e m o n s t r a t o r: When will electrons move?

S t u d e n t: If given a path, electrons dislodged from the parent atom will move.

D e m o n s t r a t o r: Well, what do you know about the electric current?

S t u d e n t: The electric current is a quantity of electrons flowing in a circuit per second of time.

D e m o n s t r a t o r: And what is the unit of measure for current?

S t u d e n t: The unit of measure for current is the ampere. One coulomb passing a point in a circuit per second, the current strength is I ampere. The ampere is therefore a rate unit.

D e m o n s t r a t o r: Why do the electrons move along the circuit?

S t u d e n t: The electrons move along the circuit because the e. m. f. drives them.

D e m o n s t r a t o r: When is the rate of electron flow doubled?

S t u d e n t: It is doubled, if the force is doubled. It means that other factors being constant, the current is directly proportional to the e. m. f.

D e m o n s t r a t o r: What other factor determining the magnitude of the current do you know?

S t u d e n t: This is the ease with which the electrons are allowed to pass along the circuit. This "ease" or conductivity may be defined as the number of amperes per volt in a circuit.

D e m o n s t r a t o r: And when is a current proportional to the conductivity?

S t u d e n t: All other factors being constant, the current is directly proportional to the conductivity. If the conductivity is doubled, the current will be also doubled.

D e m o n s t r a t o r: How is a magnetic field developed?

S t u d e n t: A stream of electrons in a circuit will develop a magnetic field around the conductor along which the electrons are moving.

D e m o n s t r a t o r: What does the strength of the field depend upon?

S t u d e n t: The strength of the magnetic field depends upon the current strength along the conductor.

D e m o n s t r a t o r: And what about the direction of the field?

S t u d e n t: The direction of the field is dependent upon the direction of the current flow.

D e m o n s t r a t o r: When is the current called direct or alternating.

S t u d e n t: If the force causing the electron flow is unidirectional, the current is called direct. The force changing its direction of effort periodically, the current is known as alternating.

D e m o n s t r a t o r: That will do!

EXERCISES

I. Read the following words, paying attention to the pronunciation of the vowels in italics:

*cir*cuit, *cir*cle, *cir*cumference, *cir*cular; *dou*ble, t*ou*ch, tr*ou*ble; rec*ei*ve, perc*ei*ve; f*ie*ld, bel*ie*ve.

II. Read the following words:

'constant, 'effort, 'frequent; e'lectron, ex'tent, de'velop; ,conduc'tivity, selec'tivity, produc'tivity.

III. Exercise on fluent reading:

The unit of measure, the stream of electrons, the extent of strength, per second of time, all factors being constant.

IV. Translate the following sentences, paying attention to the different meanings of the words in italics:

1. Work is measured by the product of the moving force *times* the distance through which the force acts in overcoming the resistance. 2. It is best to have the value of an alternating current or voltage vary with *time* according to the sine wave. 3. The word "phase", when properly used in a. c. terminology, refers to *time*. 4. The experiment was repeated many *times*, and the temperature conditions varied slightly. 5. With metal filament lamps the power radiated as light is nearly three *times* as great as the power radiated as heat. 6. We could study the reaction mentioned above very thoroughly because it lasted over a long *time*. 7. Large turbines have an economy of three or four *times* that of the steam units in a small plant. 8. We know that iron molecules are magnets at all *times*.

V. Translate the following sentences, paying due attention to the meaning of the words in italics:

1. The wire and the electrical source together *form* an electric circuit. 2. Until recently magnets have been made of hardened steel, molded or rolled, their *form* being of a great variety. 3. The energy being lost in the condenser as a result of dielectric hysteresis appears in the *form* of heat being generated within the dielectric. 4. Virtually all substances in liquid or solid *state* possess the property of electric conductivity to some degree. 5. One can *state* that there is no sharp distinction between conductors and insulators. 6. *The subject* of the investigation carried out was of great scientific importance. 7. In all the experiments made the scientist could *subject* the substance being tested to thermal treatment at different temperatures. 8. If the voltage gradient is made sufficiently high, one can *force* any atom to let go one electron. 9. The body was acted upon by a *force* of an opposite direction. 10. The article we shall read next time will *deal* with the development of radio engineering in our country. 11. Soviet scientists have contributed a great *deal* to the development of world science and technique.

VI. Translate the following sentences, paying attention to the proper place of the predicate in the translation:

1. In all calculations of a. c. power, the effective values of current and voltage *are used*. 2. In testing apparatus in which insulation *is*

used, or in condenser circuits, the maximum voltage *is applied*. 3. If a resistance is placed in the circuit, the lag of the maximum voltage *will be decreased*. 4. Whenever energy in any form is released, a force *is developed*. 5. Mendeleyev left blanks in his table and predicted what the characteristics of the elements, when found, *would be*.

VII. Analyse and translate the following sentences:

1. Connect the carbon and the copper in the solution to the terminals of a voltaic battery of three or four cells, the carbon being connected to the negative pole of the battery. 2. At the places where the transformation of energy is to be made, alternating current transformers are placed, the primary coils of these transformers being connected across between the two primary circuits. 3. It is usual to split up the primary coil into two or more coils and to sandwich these in between the secondary coils, or to wind the secondary coil over the primary coil, the object of these arrangements being to reduce the magnetic leakage. 4. The current being created, work has to be spent to maintain it against the resistance of the circuit. 5. Picture the free ions with their electric charges moving rapidly in different directions, one moment being in combination and the next moment free again. 6. The ions being polarized, any attempt to send more current through the cell meets with an opposing electromotive force, due to the tendency of the ions to recombine. 7. Faraday discovered that if we pass the same current through a number of electrolytic cells arranged in series, or one after the other, each containing different electrolytes, the current will liberate in each cell weights of free ions which are chemically equivalent. 8. The cell being charged, a certain quantity of electricity is passed through it. 9. The armature when would represents on the outside a smooth cylindrical surface of cotton covered wires, all placed parallel to the shaft.

VIII. State the forms and functions of the Participles and translate the following sentences:

1. The region *surrounding* one or more *charged* bodies is known as the electrostatic field. 2. The process by which the signal *being transmitted* is reproduced from the radio-frequency currents present at the receiver is called detection. 3. The electrification *produced* in a glass rod by stroking it with silk is arbitrarily called positive electrification. 4. The amount of heat *deposited* depends on the magnitude of the current and the time it flows. 5. *Being allowed* to come into contact with the rod, the pith ball is repelled by the rod. 6. When a steel *knitting* needle is stroken from one end to the other with a piece of lodestone, *using* for point of contact one of the points at which the iron filings adhere more freely, the needle acquires the property of attracting iron filings and of setting itself north and south when *suspended*. 7. *Having been impregnated*, paper can be employed in the manufacture of cables, transformer coils, etc. 8. An electron *leaving* the surface, the metal becomes positively charged. 9. Practically all metals are conductors of electricity, the conductivity *ranging* from silver, which is 1,06 times as effective as copper, to steel, which has only about 0.1 times that of copper. 10. A magnet *being broken* into two, two complete magnets result, two new poles *appearing* at the fracture.

IX. Learn the dialogue.

13. Electromotive Force

When free electrons are dislodged from atoms, electrical energy is released and made available to do work. Chemical reaction, friction, heat and electromagnetic induction will cause electrons to move from one atom to another. Scientists proved electrical energy to be released from matter by chemical reaction (batteries), heat (thermocouples), electromagnetic induction (generators), and friction (static generators). Whenever energy in any form is released, a force is developed. Electrical energy being released, a force called electromotive force (e. m. f.) is developed. An e. m. f. is present, whenever free electrons are moved from atoms, any of the abovenamed methods being used to produce such electron motion.

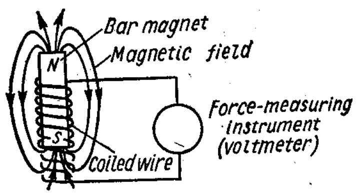

Fig. 2

If the force exerts its effort always in one direction, it is called direct; the force changing its direction of exertion periodically is referred to as alternating.

The chemical reaction in a dry cell produces a negative charge or potential on the zinc. This charge being always negative, the e. m. f. is unidirectional (one way). Heat and friction, too, are sources of a unidirectional force. Electromagnetic induction, however, is certain to produce an alternating force.

If the south end of a bar magnet (see Fig. 2) is passed into a coil of wire connected to a force-measuring instrument (voltmeter), the meter needle will move in one direction. If the south pole of the magnet is withdrawn from the coil, the needle will move toward the opposite side of the meter, thus showing the force to be alternating. The direction of force effort is seen to be dependent upon the direction in which the field is cut. The magnitude of the electrical force depends on the conditions at the source, such as the number of magnetic lines of force per unit of time.

In the battery, the determining factors are kinds of electrolytes and the kind of the metals to be used for the plates. The common dry cell is found to develop 1.5 volts of electrical force regardless of the size of the cell. Large amounts of force can be obtained only by putting many cells in series.

The force developed by the generator depends on the number of coils in the armature, on the speed of the armature, and on the strength of the magnetic field from the field magnets, i. e., the number of lines of magnetic force cut by a coil per second. The volt is known to be the unit of measure for electrical force.

Wherever an e. m. f. is developed, there is also a field of energy called an electrostatic field. This field can be detected by an electroscope, the strength being measured by an electrometer.

EXERCISES

I. Read the following words, paying attention to the pronunciation of vowels in italics:

M*ea*sure, tr*ea*sure, pl*ea*sure [e]; ab*o*ve, l*o*ve [ʌ].

II. Read the following words:

de'termine, e'xamine, 'measurable, a'vailable, ob'tainable, 'unidi'rectional, 'uni'lateral, 'uni'versal.

III. Give words of the same stem and translate them:

to obtain, to measure, to move, to induce, to determine, to develop, to exert, to direct, to depend, to unite, to cause.

IV. Find in the text synonyms for the following words and give some examples of their use:

to make, substance, to name, force, to indicate, movement, to receive, amount, since, usual, to apply, velocity, dimension, to define.

V. Give different meanings of the following words. Make up a few sentences to illustrate their use:

above, cause, since, present.

VI. Find the Infinitive constructions in the following sentences and translate the sentences:

1. We know the ampere to represent the rate of electricity flow through the circuit. 2. Electric pressure or e. m. f., which is measured in volts, causes electricity to flow. 3. The two irons in question lie parallel to the axis of the coil, and assuming their permeabilities to be constant, the pole strength will be proportional to the current. 4. The only force which can make an electron move is that due to the fields of other electrons. 5. Above about 500 kilocycles it is difficult to make an arc develop appreciable negative resistance. 6. To make an electric current flow continuously along a wire, a continuous supply of electrons must be available at one and a continuous supply of positive charges at the other. 7. The passage of current through a conductor of wire causes heat to be generated in it. 8. Heating causes a magnet to be demagnetized. 9. To avoid possible breakdowns of the insulation, the practice is to put extra insulation on the end turns to enable them to withstand the extra stress to which they are subjected at the moment

of switching on. 10. A compensator allows the motor to take an excess current without putting a heavy overload on the mains. 11. Some tests enable the voltage absorbed by the impedance of the winding to be determined in addition to regulation. 12. If a current is passed through a coil of wire wound around a piece of iron, the latter will be found to be magnetized in a definite direction. 13. The magnetic field in the above case may be considered to be radial across the air gap. 14. Pure annealed copper is said to have 100 per cent conductivity. 15. Faster moving molecules meet oftener and being of higher energy content are more likely to react on meeting. 16. If the amount of inductance and capacity are so small that their influence upon the current is negligible compared to the influence of the resistance the circuit may be considered to have nothing but resistance opposing the flow of current. 17. Copper and silver electrodes are certain to give a higher resistance gap than such metals as zinc, magnesium and so on. 18. The liquid particles seem to have a greater attraction for the solid than for their own molecules, this force of attraction between molecules of different kinds being called adhesion. 19. Having been rubbed many substances were proved to behave as amber does. 20. The beginner has probably noticed that if he hears the word "current" he is likely to hear the word "voltage" or "resistance". 21. A generator appears to be a device by which mechanical energy is transformed into electrical energy. 22. Incandescent lamps are seen to be examples of the application of the heating effect of an electric current, a conversion of energy taking place from an electrical form to that of heat. 23. In many circuits the potential distribution changes with frequency and as the electrostatic energy (hence capacity) depends upon the potential distribution, the capacity may be expected to change with frequency. 24. In the majority of elementary calculations the inductance or the coefficient of self-inductance is assumed to be a constant for a given coil. 25. Two coils are known to possess a mutual inductance of 1 henry, if 10^8 linkages are set up in one coil due to a current of one ampere in the other. 26. When the two conducting bodies are separated by a dielectric they are said to possess capacity and the combination is called a condenser. 27. If, as in the above case, the voltage happens to be switched on at the instant when it passes through zero certain abnormal conditions are momentarily set up. 28. If the magnetic force is reversed the induction density appears to lag behind the magnetic force.

VIII. Be ready to speak about:

1. Different methods of releasing electrical energy from matter. 2. The development of the electromotive force. 3. The direction of the e. m. f. 4. Batteries as a source of electrical energy. 5. The force developed by the generator. 6. The electrostatic field.

IX. Describe the formation of direct and alternating electromotive forces (see Fig. 2 on p. 42).

14. Electricity in Motion

When an electric charge is at rest, it is spoken of as static electricity, but when it is in motion, it is referred to as an electric current. In most cases, an electric current is described as a flow of electric charges along a conductor.

Such is the case, for example, in the experiment of charging an electroscope from a distant point by means of a long copper wire and a charged rubber rod. This experiment is explained by stating that electrons already in the wire are pushed along toward the electroscope by the repulsion of electrons from behind. *No sooner does this current start*[13], however, that the negative charge of the rod is dissipated and, the current stops flowing.

To make an electric current flow continuously along a wire, a continuous supply of electrons must be available at one end and a continuous supply of positive charges at the other. This is like the flow of water through a pipe; to obtain a continuous flow a continuous supply of water must be provided at one end and an opening for its escape into some receptacle at the other. The continuous supply of positive charges at one end of a wire offers a means of escape for the electrons. If this is not provided for, electrons will accumulate at the end of the wire, their repulsion back along the wire stopping the current flow.

There are two general methods by which a continuous supply of electrical charge is obtained; one being by means of a battery, and the other being by means of an electric generator. The battery is known to be a device by which chemical energy is transformed into electrical energy and the generator as a device by which mechanical energy is transformed into electrical energy.

EXERCISES

I. Find in the text synonyms for:

movement, to be called, for instance, with the help of; to be similar to, to get, to provide, instrument, to change into.

II. Find in the text antonyms for:

in motion, attraction, to finish, to discharge, to accumulate.

III. Translate the following sentences, paying special attention to the different meanings of the words and expressions in italics:

1. If a continuous supply of positive charge at one end of a wire is not *provided for*, electrons will accumulate at the end of the wire. 2. The continuous supply of positive charge at one end of a wire *provided* a means of escape for the electrons. 3. Electrons will accumulate at the end of the wire *provided* there is no continuous supply of positive charge. 4. The laboratory *provided with* the most modern equipment gives all the possibilities for studying electricity in motion. 5. *In the case* just considered we had *to do with* electricity at rest. 6. *In most cases* an electric current is described as a flow of electric charge along

a conductor. *Such is the case*, for example, in the experiment of charging an electroscope from a distant point by means of a long copper wire and a charged rubber rod. 7. *In case* one end of the wire is made positive, by removing electrons from it, the shortage of electrons at this end will cause free electrons to be attracted toward it. 8. If, *as is usually the case*, the number of turns of wire in the secondary exceeds the number of turns in the primary, the average voltage of the secondary will be many times higher than the direct-current voltage impressed on the primary. 9. Atoms may have the same number of protons and a different number of neutrons *in which case* they are atoms of the same elements but of different weights.

IV. Translate the following negative sentences:

1. No sooner does this current start, however, than the negative charge of the rod is dissipated and the current stops flowing. 2. No additional device is needed to make the voltage increase. 3. No dangerous increase of the voltage is to be expected in the test under consideration. 4. No current is drawn from the cathode when cold. 5. No material is a perfect insulator. 6. No matter how badly distorted the current and voltage may be, however, the wattmeter readings will be a correct measure of the power actually applied.

V. State the functions of the Infinitives in the following sentences. Translate these sentences into Russian:

1. To magnetize a magnetic body or to create a magnetic flux in a circuit always requires an expenditure of energy. 2. To increase the reliability of large industrial centres, the latter are fed from several power plants joined into a common network. 3. An automatic control system may be regarded as consisting of two main parts, the plant to be controlled and the controlled unit. 4. The usual procedure is to start checking at the last audio amplifier and work back. 5. One knows to a high degree of certainty that being accelerated to a sufficiently high velocity an electron may have enough kinetic energy imparted to it to knock one or more electrons out of any material with which it comes in contact, either a metal conductor or an insulator. 6. It is mostly impossible to make some types of meters function properly at the very high frequencies used in radio work. 7. The force that causes electrons to move is called the difference of potentials or e. m. f. 8. Control systems have already been shown to differ considerably as functions of control problems and plant characteristics. 9. In a battery the determining factors are kinds of electrolytes and the kind of the metals to be used for all plates.

VI. Put questions to the text.

VII. Write a summary of the text.

VIII. Translate into English:

Чтобы заставить электрический ток непрерывно протекать по проводнику, необходимо создать разность потенциалов на концах проводника. Имеются два метода, посредством которых можно получить разность потенциалов: посредством батареи или электрического генератора. Известно, что батарея преобразует химическую энергию в электрическую. Мы знаем, что генератор преобразует механическую энергию в электрическую.

15. Electric Circuits

The concepts of electric charge and potential are also essential in the study of electric currents. When an extended conductor has different potentials at its ends, the tree electrons of the conductor itself are caused to drift form one end to the other. In order for this flow to continue it is necessary that the potential difference be maintained by some electrical source such as an electrostatic generator, or, much more frequently, a battery or a direct-current generator. The wire and the electrical source together form an electric circuit, the electrons drifting around it as long as the conducting path is maintained. In effect such a flow of electrons constitutes an electric current.

Batteries and direct-current generators are sources of potential difference which urge the electrons around a circuit continually in one direction, producing a unidirectional current. For this reason such a source is said to have a fixed polarity, one terminal being called positive and the other negative. If it is desired to reverse the flow, then the terminals of the circuit must be reversed with respect to the source.

From the early days of electrical science, current has been regarded as a flow of electricity from the positive terminal to the negative terminal in the external circuit connected to a source. Now we know a current through a conductor to be actually a movement of electrons, and since these have negative charges, they travel around the external circuit from the negative terminal to the positive terminal. The electron flow is, therefore, opposite to the conventional direction of current, making it necessary, in order to avoid confusion, to distinguish one from the other by name.

EXERCISES

I. Translate the following words:

difference, polarity, operable, negligible, clockwise, interconnect, exchange, coordinate, mismatch, predetermine, dislocate, detune, counterbalance, man-made, blueprint, viewpoint, ups and downs, to upset, to set up, feedback, whatever, elsewhere.

II. Find in the text:

a) Nominative Absolute Constructions;

b) Sentences with Complex Subject and Complex Object with the Infinitive.

III. Find in the text synonyms for:

to support, constantly, to wish, often, hence, really, standard, movement.

IV. Translate paying attention to the different meanings of the words in italics:

1. Many different kinds of tubes have been invented *since* the introduction of the two-electrode tube. 2. Silver is the best conductor *since* it offers the least resistance to the flow of current of electricity. 3. *Since* the commutator is connected to the armature coil, it rotates with it. 4. An electromotive force *causes* the electrons to move in some definite direction. 5. The moving of the magnet *causes* the electron flow. 6. Force and motion always go together; one is a *cause*, the other a result. 7. The *cause* of Lenin is invincible. 8. Different kinds of instruments are used to *measure* electric current. 9. A volt is a *measure* of electromotive force.

V. Compose sentences with the following expressions:

in effect, for this reason, with respect to, in order to.

VI. Memorize the following terms:

terminal, electric circuit, potential difference, electrical source, direct current generator.

VII. Be ready to describe electric circuits.

VIII. Make up a plan of the text.

IX. Retell the text according to your own plan.

X. Translate into English:

Ток в электрической цепи является потоком электронов. Его величина определяется скоростью этого потока, которая связана с величиной приложенной э. д. с. Единицей измерения тока является ампер. Известно, что поток электронов в цепи создает магнитное поле вокруг проводника, по которому они движутся.

16. Ohm's Law

Georg Ohm (1787—1854) was a German physicist. His enunciation of the law in 1827 aroused such bitter antagonism that he lost his position. Years later, when his work was corroborated by other scientists, he was honored by a professorship in physics at the University of Munich. Ohm stated his law having no reliable voltmeters, ammeters or batteries. He employed thermocouples to generate currents.

What is an ohm? Every electrical conductor opposes the passage of electric charges through it. This opposition arises because of the moving charges colliding with the atomic nuclei and other particles of the conductor. *In so doing*[14], the moving charges give up energy, which appears as heat. According to Ohm's law, electrical resistance is the ratio of the potential difference to the current for a conductor at a given temperature. The ohm, the practical unit of resistance, is defined in terms of the ampere and the volt, as follows:

One ohm is the resistance of a conductor through which the current is 1 ampere when the potential difference across the ends of the conductor is 1 volt.

One ohm equals 1 volt per ampere.

This is the well known and fundamental law in electricity which makes it possible to determine the current flowing through a circuit when the resistance in the circuit and the potential difference applied to it are known. What Ohm discovered was that the ratio of the potential difference between the ends of a metallic conductor and the current flowing through the metallic conductor is a constant. The proportionality constant is the electrical resistance.

$$\text{Resistance} = \frac{\text{potential difference}}{\text{current}}$$

Symbolically, Ohm's law is often written

$$R = \frac{V}{I}, \text{ or } 1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ ampere}}.$$

Using Ohm's law is of great importance because of its being generally applied to so many electrical phenomena. One of its simplest applications is using a dry cell directly connected by wires to a small light bulb. The battery maintains a potential difference of 1.5 volts across the lamp. The electron current flowing through the circuit being 0.5 ampere, the resistance of the circuit is

$$R = \frac{1{,}5 \text{ volts}}{0{,}5 \text{ amp.}} = 3 \text{ ohms.}$$

Although the resistance as found here is assumed to be the resistance of the light bulb, it really includes the resistance of the connecting wires, as well as the resistance of the battery. In practice one usually uses wires of sufficiently low resistance that they can be neglected in most calculations. If they are not small, they cannot be neglected and must be added in as part of the R in Ohm's law.

Although electromotive force and potential difference are both measured in volts there is a real distinction between them. Electromotive force is defined as the work per unit charge done by the battery or generator on the charges in moving them around the circuit. Potential difference between two points is defined as the work per unit charge done by the charges in moving from one point to the other.

If any two of the three quantities: resistance, current and potential difference are known for a curcuit, the third can always be determined by substituting in Ohm's law. In other words, any one of the three factors may be the unknown, and Ohm's law may be written in any one of three ways:

$$I = \frac{V}{R}, \ R = \frac{V}{I}, \ V = IR.$$

EXERCISES

I. Read the following words, paying attention to the pronunciation of the letter *i*:

determine, examine, engine, turbine, imagine; opposite, definite, requisite.

II. Read the following words:

metallic, economic, electric, basic, scientific, numeric, electronic, parasitic, conductivity, resistivity, availability, responsibility.

III. Translate the following groups of words of the same stem:

science, scientist, scientific; to state, state, statement; to rely (upon), reliable, reliability, unreliable; to employ, employer, employee, unemployed, unemployment; to generate, generator, generation; to conduct, conductor, conductance, conductivity; to move, movement, motion; to collide, collision; to appear, appearance, to disappear, disappearance; to resist, resistor, resistance, resistivity, resistant; to differ, different, difference; to define, definition, definite, indefinite, indefinitely; equal, to equal, equally, equality, equation, to equalize, equalization; to assume, assumption; to measure, measure, measurement, measurable.

IV. Translate the following sentences, paying attention to the different meanings of the words in italics; give some examples:

1. In practice *one* usually uses wires of sufficiently low resistance that they can be neglected in most calculations. 2. Potential difference between two points is defined as the work per unit charge done by the charges moving from *one* point to the other. 3. The device in question is more efficient than the *one* used in the previous experiments. 4. *One* could hardly expect to measure voltage, say, 5 volts to even an average degree of accuracy with a voltmeter having 500 volts as its maximum. 5. Suppose *one saws* a piece of wood with a rapid motion. As a result, the *saw* begins to grow hot. 6. *One* of the greatest bulwarks of the atomic theory was furnished by the Russian chemist D. I. Mendeleyev. 7. *For* most substances the permeability has a value of unity, nickel, iron and cobalt being the notable exceptions. 8. The coulomb is the quantity of electricity transported by a current of one ampere flowing *for* one second. 9. In most electric apparatus depending on the magnetic field *for* its operation the field is produced by currents flowing in

coils. 10. Electrical generators convert mechanical energy of rotation into electricity directly by way of magnetism, *for* magnetism serves as an intermediate step between the mechanical energy to be applied to the generator and the electrical energy on the wires leading to it. 11. *For the sake of* clarity each armature winding is shown as a single loop. 12. Let us assume *for the sake of* simplicity that a vibrating tuning fork is placed in front of the microscope. 13. The nuclear β rays proper, which have a continuous spectrum, present the theoretical physicist with a puzzling problem. *For*, if particles of all possible energies leave the nucleus of the atom, the nucleus cannot remain as a unique structure of definite energy.

V. Analyse the Gerunds in the following sentences and translate the sentences:

1. *Earthing* is of vital importance in all electrical systems and for all apparatus. 2. It should be noted that earth does not mean merely *touching* the ground, strata or rocks, but metallic contact with the continuous earth system of a mine and the "earth" of the surface. 3. The method of *connecting* the armature and field winding of the series motor is exactly the same as for the corresponding generator. 4. *Emitting* a beta particle does not alter the mass number. 5. *Screening* cables is obtained by wrappings of flexible tinned copper. 6. On *dipping* a magnetized needle into iron filings it is seen that iron filings adhere most strongly at the ends of the needle. 7. A magnetic field equal to 10 oersteds is represented by *drawing* 10 lines of force per square centimeter. 8. Every substance capable of *being magnetized* is assumed to consist of a very large number of molecular magnets, probably no longer than the molecules out of which the substances are made. 9. If two rubber rods, electrified by *being rubbed* against fur are brought near each other, they will be found to repel each other. 10. Upon *breaking* the magnet into still shorter pieces we still get complete magnets. 11. *Hammering, bending* or *twisting* an iron rod when it is near a magnet, increases its magnetization. 12. Electromotive force is defined as the work per unit charge done by the battery or generator on the charges in *moving* them around the circuit. 13. Referring to the Einstein's equation, it is evident that the velocity of emission is just zero when the energy of one photon is just equal to the energy lost by the electron in *being emitted*. 14. *Breaking* the circuit causes sparking. 15. Many substances after *being rubbed* behave as amber does. 16. A number of methods have been devised for *observing* atomic collisions. 17. The electrons flow to the cathode bacause of its *having lost* electrons and *being* less negative than the negative side of the battery. 18. Even the best conductors of electricity *offering* some resistance to the current flow must be kept in mind while *dealing* with electrical phenomena. 19. In *considering* power in electrical circuits one should remember of all electrical devices *having* resistance.

VI. Analyse and translate the following sentences:

1. We know of silver and copper being very good conductors of electricity. 2. Only in the middle of XIX century the fact of the quantity of heat produced being proportional to the work done was definitely stated. 3. Mica is widely used as a dielectric in high grade condensers because of its having high voltage strength. 4. The p. d. across the terminals of a cell being less than the e. m. f. of the cell applies equally to a generator or, indeed, any source of e. m. f.

5. Marie Sklodowska's having made numerous experiments resulted in isolating two new elements. 6. When a bar of iron is thrust into a fire it becomes heated due to the atoms comprising the bar becoming agitated. 7. Charged particles are seldom found at rest in an electronic device. The mechanisms by which they are formed nearly always insure their having some residual velocity.

VII. Put 5 questions to the text and answer these questions.

VIII. Define Ohm's Law.

IX. Learn to read the following formulas:

$E = I \times R$ is read: E equals (is equal to) I multiplied by R (or times R);

$I = E : R$ is read: I equals E divided by R;

$I \times R$ is read: I multiplied by R or I times R;

$\frac{E}{I}$ is read: E over I, or E divided by I.

X. Note the plural of the following foreign nouns:

a datum — data; a phenomenon — phenomena; a formula — formulae; an axis — axes; radius — radii; nucleus — nuclei; locus — loci.

XI. Be ready to speak about: G. Ohm and his law.

17. Charged Body

DIALOGUE

D e m o n s t r a t o r: What body is considered to be negatively charged and what body is considered to be a positively charged one?

S t u d e n t: From the electric viewpoint a negatively charged body is one having more than its normal number of electrons and a positively charged body is one having less than its normal number of electrons.

D e m o n s t r a t o r: Is the normal atom charged or not?

S t u d e n t: The normal atom is not charged. This means that it does not exert any attractive or repulsive force on the other atoms.

D e m o n s t r a t o r: What do you know about the structure of the atom?

S t u d e n t: The structure of the atom is as follows. In the centre part of the atom are grouped some positive and negative particles, called protons and neutrons respectively. The nucleus is surrounded with a cloud of electrons. So an atom having an equal number of positive and negative particles shows no electrical charge, the negatives and the positives just neutralizing each other.

D e m o n s t r a t o r: Why is the nucleus said to be positively charged?

S t u d e n t: It is said to be positively charged because the center part of the atom always consists of protons and neutrons only.

D e m o n s t r a t o r: What determines the nature of the atom?

S t u d e n t: The number and arrangement of the outer electrons as well as protons and neutrons determine what the atom is whether hydrogen, oxygen, copper, gold, etc.

D e m o n s t r a t o r: How do different elements differ?

S t u d e n t: All elements we know differ only in the number and arrangement of protons and electrons.

D e m o n s t r a t o r: What do you know about tungsten?

S t u d e n t: Tungsten has very many electrons placed in certain well-known complex arrangements.

D e m o n s t r a t o r: What happens if one electron is removed from the atom by some means or other?

S t u d e n t: In this case the balance between positive and negative charges is destroyed; an excess of positive charge exists on the atom, the atom is positively charged. The particle formed after one electron had been removed from the atom is called an ion.

D e m o n s t r a t o r: That's right.

EXERCISES

I. Read the following words:

'viewpoint, 'certainly, 'frequently, 'nucleus, 'neutralize, 'mercury, re'pulse, re'pulsive, e'xert, e'xist, ex'hibit, re'markable; su 'fficient, ex'cess, de'termine.

II. Give derivatives from the following words and translate them:

to attract, to repel, certain, remark, equal, to close, to exceed, to lose, proper.

III. Give synonyms for the following words and use some of them in sentences:

viewpoint, shape, substance, degree, amount, to consist of, sufficient, whereas, complex,peculiar, almost, define, tightly, because of.

IV. Make up sentences, using the following word groups:

for the most part, in question, in excess of, as a whole.

V. Translate the following sentences, paying attention to the different meanings of *but*:

1. It seems that the electron is nothing *but* electricity. 2. If *but* a few of the atoms of a body have had an electron removed the body has a small charge. 3. One can easily note how voltage increases during the first quarter-turn *but* then decreases during the next quarter turn. 4. The operator saw all the tubes *but* one function in the proper way. 5. We expect the current cycle and the voltage cycle to finish in step if they start in step. *But* in many a. c. circuits the current cycle does not get started as soon as the voltage cycle.

VI. Translate the following sentences, paying attention to the tense-form in passive:

1. The readings of every indicating instruments *are obtained* in a minimum of time. 2. The nature of the material determines the ease with which electrons *are allowed* to pass. 3. The space surrounding a charged body, in which another charged body *is acted upon* by a force tending to move it, constitutes an electric field. 4. The action of some instruments *cannot be much relied upon* because of their being not sensitive enough. 5. The choice of the method *is highly influenced* by the results required. 6. The space surrounding a charged body *is called* an electric field of force. This electric field *may be thought* of as consisting of a number of lines of force representing the directions in which the electric force acts. 7. An e. m. f. induced in a stationary electric circuit, by a change in the number of magnetic lines, linking with it, *is reffered to* as a "statically induced" e. m. f. 8. A number of lines of magnetic intensity *are spoken of* collectively, as "magnetic flux" and the number per square centimetre of cross section as the "flux density".

VII. Translate the following sentences:

In case there is no current in a conductor, there can be no electric field within it. 2. Unless the opposing force just balanced the impressed force, a steady state would not be obtained. 3. If each atom in an orange measured 1 inch in diameter, the orange would be as large as the Earth. 4. If the two charged plates of a condenser had been "short-circulated" by a wire a momentary current would have been established through the wire. 5. If the coil were wound on an iron frame, and provided there were a soft iron core in a centre, the field would, of course, be much stronger. 6. It is necessary that the power apparatus should be operated at maximum efficiency. 7. The transmission of information by radio waves requires that some means be provided to control the radio waves by the desired intelligence. 8. Power apparatus is usually operated at maximum efficiency lest the generating apparatus should burn up. 9. Sometimes the electron acts as though it were a wave. 10. Should the resistance on the load increase, the efficiency will be improved. 11. If a magnet is brought near any substance traversed by an electric current, this substance will generally be acted upon by a force tending to move it.

VIII. Translate the following sentences, paying attention to the meanings of the modal verbs with Perfect Infinitives:

1. The experiment *must have been done* in a wrong way because of the data obtained being in contradiction with Lenz's law. 2. The voltage *may have been* too *high*, the insulation being broken down.

3. The friction between the wax and the flannel *must have rubbed off* some electrons of the flannel molecules and left them on the surface of the wax. 4. The operator *should have examined* the trouble caused due to the conductor being overheated. 5. This magnetized body *may have exerted* some attractive or repulsive force on the other one. 6. The alpha grains *must have formed* during the 30-sec cooling required to reach a temperature below which diffusion was negligible. 7. To get better results another method *ought to have been applied.* 8. It *must have been known* for centuries that a colored glass is cooler at the bottom of a pot than a colorless glass.

IX. Be ready to speak about a charged body.

X. Be prepared to take the parts of student and demonstrator according to the dialogue.

18. Induced Electric Currents

The discovery of induced electric currents goes back more than one hundred years to 1831 and the experiment of Michael Faraday. A straight bar magnet plunged into a coil of wire was found to produce an electric current. The N pole of the magnet being plunged into the coil, a galvanometer needle deflects to the right. It being withdrawn, the needle deflects to the left, indicating a current in the opposite direction. If the S pole be moved down into the coil, the needle deflects to the left and as it is withdrawn, the deflection is to the right.

The relative motion of the coil and magnet is what produces the current and it makes no difference whether the coil alone moves[15], whether the magnet alone moves, or whether they both move. In either case, if the relative motion ceased, the current would stop. A "somewhat old-fashioned" way of describing the action is to say that only when a wire is cutting the line of force is there an induced e. m. f. A somewhat more acceptable statement at the present time is, in effect, that only when the total magnetic flux linking a closed electrical circuit is changing is there an induced e. m. f.

A flexible wire connected to an ammeter, and held in the hands, is moved in various ways across the pole of a magnet. In case a straight section of the wire were held over the N pole and moved to the right, an electron current would flow in the one direction. Were the wire moved in the opposite direction, the induced e. m. f. and current would reverse direction. Should the wire be moved vertically upward or downward, parallel to the magnetic induction, no current will flow. In other words, there is an induced e. m. f. only when the total number of lines of induction through the closed circuit is changing.

A current being produced means that electrical energy has been created. It has been created at the expense of mechanical work, for in moving the wire across the field, a force F had to be exerted for a distance S. The faster the wire moves, and the stronger the field through which it moves, the greater is the required force and the greater is the induced e. m. f. and the resultant electron current. Provided the wire stops moving in mid-field the e. m. f. drops to zero. These are the essential principles of the electric generator.

EXERCISES

I. Read the following words with the stress:

1) on the first syllable:

magnet, total, upward, downward, ammeter; various, vertical, parallel; demonstrate, indicate, generate, relative, opposite;

2) on the second syllable:

deflect, alone, withdraw, produce, perform, connect, reverse, create, expense, exert; resultant, electron, electric, essential, acceptable, experiment.

II. Make a written translation of the second passage of the text beginning with: "The relative motion of the coil..."

III. Find in the text synonyms for the following words and give some examples of their use:

to show, movement, to stop, strength, to connect, different, to demand, in fact, quick.

IV. Make adjectives from the following verbs, adding the suffix *-able* and translate them:

to accept, to rely, to measure, to reason, to operate, to apply, to move, to suit, to appreciate, to consider, to notice, to allow, to obtain, to attain, to vary.

V. Give antonyms for the following words:

upward, internal, outside, slow, open, to move, the same, to increase, like, right.

VI. Translate the following sentences, paying attention to the meanings of the words in italics; give your own examples:

1. *Whether* one plate of a 1-farad capacitor is grounded *or not*, the potential difference between the plates will be one volt when one plate has a positive charge of one coulomb and the other plate has a negative charge of one coulomb. 2. It should be pointed out that it makes no difference in the above treatment *whether* the wire moves through a stationary magnetic field *or whether* the field moves across a stationary conductor. 3. With a metallic sphere, *whether* solid *or*

hollow, the static charge spreads uniformly over the surface. 4. Amplifiers are also classified as to *whether* they are tuned or untuned, i. e., *whether* they amplify a narrow or a wide band of frequencies, respectively.

VII. Translate the following sentences, paying attention to the different meanings of *should* and *would*:

1. Some instruments, if actuated by an alternating current, *would* tend to oscillate between a certain direct reading and the equal reversed reading. 2. The calculation of power used is not easily measured by ammeters and voltmeters, either a wattmeter or the oscillograph *should* be used. 3. A one microfarad condenser in series with two ohms *would* have a time constant of 0.000.002 second, that is, the current *would* rise instantaneously upon closing the switch, to some value (depending upon the voltage used in charging) and in 0.000.002 second *would* have fallen to 37 per cent of this value, and in a correspondingly short time *would* have dropped to practically zero. 4. The charging of a condenser connected to a source of continuous e. m. f. *would* take place instantaneously, if there were no resistance in the circuit. 5. A current of an ampere *would* have to flow only one millionth of a second to charge the condenser to one volt potential difference or one microampere flowing for one second *would* charge it to the same extent. 6. It is necessary that the voltmeter *should* be connected in parallel with the battery and the control resistance. 7. It *should* be *noticed* that every atom of matter is charged with minute particles of negative electricity which are called electrons. 8. The screen grid *should* be at a lower potential than that of the plate. 9. Such a coil arrangement *would* tend to make the circuit unstable since there *would* be the possibility of feedback of energy from the plate current to the grid circuit through the tube interelement capacity. 10. In order to limit the amount of current flowing in the filament plate circuit it is necessary that the potentiometer *should* be of a high resistance. 11. The grid must be at a higher potential than that of the filament or the electrons *would* be drawn to it. 12. *Should* the temperature of the filament increase, the magnitude of the electron flow will increase. 13. Ventilating ducts in generators are necessary lest the winding *should* get overheated. 14. The resistance of the machine was not increased lest the voltage *should* increase. 15. Care *should* be taken that proper values are applied for efficient generation.

VIII. State the kind of subordinate clauses in the following sentences and translate the sentences:

1. The number of electrons emitted from the filament in a unit time depends upon the substance it is made of and upon its temperature. 2. When a straight spring is pulled to one side and released, the kinetic energy it gains upon straightening keeps it moving and it tends to the other side. 3. In the type of rectifier we are going to discuss the internal resistance of the tube varies with the power demand upon it. 4. In the synchrotron the protons continue to go around the chamber, gaining energy each time they pass the accelerating section. 5. The number of times per second the current reverses itself is known to be the frequency and is determined by the speed of the armature and the number of field poles. 6. As the amplitude of the alternating current approaches that of the continuous current the negative resistance it encounters decreases in value. 7. We know copper is very nearly as

good a conductor as silver. 8. By elastic energy is meant the energy possessed by bodies by virtue of the endeavour they make to recover their original shape or size, when deformed.

IX. Answer the following questions:

1. When was the discovery of induced electric currents made? 2. With whose name is it associated? 3. When does the galvanometer needle deflect to the right? 4. When does it deflect to the left? 5. What produces the current? 6. When is there an induced e. m. f.? 7. How is the current created? 8. When does the e. m. f. drop to zero? 9. What are the essential principles of the electric generator?

X. Retell the text.

19. Lenz's Law

Lenz's law might have been predicted from the principle of the conservation of energy. When you move a magnet toward a coil and thus induce a current in its windings, the induced current heats the wire. In order to supply the energy to do this, you must do work in overcoming an opposing force. If the force did not oppose the motion, you would create energy. Thus the magnetic field of the induced current is seen to oppose the change.

Lenz's law and the right hand rule can be used to determine the direction of an induced current. The north pole of a magnet being moved closer to a coil, the induced current causes a field which opposes the motion, a north pole being produced on the nearer face. To cause this north pole, magnetic lines must emerge from this face of the coil. Now grasp the coil with your right hand, so that your fingers point in the direction of the induced magnetic field. Your thumb will point in the direction of the current, that is, counterclockwise.

The Induced Current Opposes the Change. A magnet pole being moved toward one face of a coil, the current induced in the coil produces a magnetic field. Moreover, this field always opposes the change of magnetic flux that is occurring. For example, move the north pole of a magnet closer to one face of a coil. The induced current will be counterclockwise and will oppose the change of flux through the coil. Remove the bar magnet, and the induced current in the coil will be clockwise, again opposing the change. This rule is expressed by Lenz's law, as follows:

Whenever a current is induced, its magnetic field opposes the change of flux.

EXERCISES

I. Read the following words, paying attention to the pronunciation of the letters in italics:

[s] clo*s*er, ca*s*e, ba*s*ic, u*s*e, increa*s*e, decrea*s*e, relea*s*e;
[u] f*u*ll, p*u*ll, p*u*sh, p*u*t;
[u:] r*u*le, bl*ue*, tr*ue*.

II. Pick up synonyms out of the following list of words and use some of them in sentences:

to predict, movement, force, thus, for instance, reason, to eliminate, cause, strength, to supply, to foretell, motion, to provide, variation, to use, to determine, close, in this way, change, near, to define, to apply, to show, to occur, for example, to remove, to point, to take place.

III. Pick up antonyms out of the following list of words:

right, north, clockwise, upward, to insert, difficult, downward, counterclockwise, left, south, to remove, to cool, near, easy, to heat, far.

IV. Underline the affixes in the following words and translate the words:

invaluable, undesirable, unreliable, unachievable, impossible, immeasurable, irregular, irresponsible, irrespective, unnatural, interconnection, interrelation, to excavate, to superimpose, superheat, supersonic, to underestimate, to underline, to overrate, to overcharge, to mislead, to misuse, to misunderstand, discharge, to disappear, to dismount, to reconstruct, to retune, to detune, to demodulate, to counterclockwise, likewise, otherwise.

V. Translate the following sentences; observe the different meanings of the verb *to do*:

1. When the molecule is placed in the electric field, the electrons try to move and *do* so for an instant. 2. If only a few of the insulator's molecules *do* release one electron each, the insulator at once completely breaks down and becomes a conductor. 3. If by some means we can change the current in a coil without changing the flux rapidly, then the current may rise and fall as suddenly as it *does* in a purely resistive circuit. 4. The electrons, the motion of which constitutes the current, *do* not actually pass from one plate of the condenser to the other through the dielectric. 5. An important question for the radio engineer to consider has *to do* with the shape of current which flows in a circuit connected to an alternator. 6. The emission or evaporation of electrons takes place at lower temperatures than *does* that of atoms.

VI. Translate the following sentences with an emphatic inversion, beginning with predicatives expressed by participles:

1. Linking the two local circuits is the transmission circuit which contains two wires, and the large windings of the two induction coils. 2. Moving around the nucleus, and at a considerable distance from it are the rest of the electrons required to make the atom neutral. 3. Included for comparison are the L-cathode emission densities at the same temperatures and field strength. 4. Superimposed upon the dominant thermionic emission is a small amount of emission caused by the in-

creasing positive potential of the anode. 5. Rotating with the lenses is a pair of double ended reflecting prisms, each of which directs the light beam from the corresponding lens forward a photocell assembly located at the front of the instrument.

VII. Translate into English:

Было обнаружено, что прямой полосной магнит, перемещающийся в катушке из проволоки, создает в ней электрический ток. Это взаимное передвижение магнита и катушки и создает этот ток. Если бы это относительное движение прекратилось, ток перестал бы течь. Чем быстрее двигается катушка, тем больше наведенная э. д. с.

VIII. Put 5 questions to the text.

IX. Formulate Lenz's Law.

X. Prepare a short information on Lenz's biography.

20. Self-Induction

An emf can be induced by varying the number of magnetic lines threading through a circuit, the induced current always opposing the change that is occurring, no matter what causes the change of magnetic flux. It may be due to the motion of a magnet or to the change of current in a nearby electrical circuit as in the transformer. The change of magnetic flux may also be due to a change of current in the coil itself, this effect being known as self-induction.

Suppose several hundred feet of wire, in a single loop, to be connected in series with an incandescent lamp, a 115-volt direct-current source, and a switch. The switch being closed, the current in the circuit will increase, in a few millionths of a second, to a steady value determined by Ohm's law. Now let this wire be wound onto an iron rod to form a coil. When the switch is again closed, the current will increase to the same final value as before, but the time required will be several hundredths of a second. In the coil there are hundreds of turns of wire, side by side. The current in each turn causes magnetic lines that thread through the other turns. An increase of current in any loop varies the flux through all the others, the change of flux of magnetic lines generating an emf. This induced emf opposes the change of current.

Self-induction is known to oppose not only the increase of current in a coil but the decrease also. The circuit being opened, the current will not stop instantly. The forward induced emf will cause a spark to appear at the switch.

In order to demonstrate self-induction, connect a large electromagnet and an incandescent lamp, in parallel with each other, through a resistor to a direct-current source. When you close the switch, at first the increasing current through the coils of the electromagnet increases the flux, thus generating an opposing emf. Self-induction impedes the current through the coil. Most of the current flows through the lamp, which glows brightly. The current having become constant, most of the current flows through the coils, and the lamp becomes dim. The switch being opened, the flux through the coils will decrease rapidly. The induced emf will make the lamp glow brightly for an instant.

EXERCISES

I. Find in the text Infinitives, Gerunds and Participles, state their forms and functions and analyse them.

II. Give synonyms for the following words:

motion, to oppose, to occur, to be due to, to call, several, to connect, steady, to determine, to require, value, to vary, to decrease, to stop, constant, rapidly.

III. Find in the text antonyms for:

never, increase, to open, to start, different, backward, to separate, slowly, bright, before, unparallel.

IV. State the kind of the subordinate clauses and translate them properly:

1. The relative motion of the coil and magnet is what produces the current. 2. What Ohm discovered was that the ratio of the potential difference between the ends of a metallic conductor and the current flowing through the metallic conductor is a constant. 3. When the temperature is reduced, scattering by the impurities is predominant. 4. As the temperature of the diode is increased, the lattice atoms are in more rapid motion. 5. Once a molecule has formed, it will move about and behave as a unit particle under various physical conditions. 6. To avoid any trouble the operator should always check up whether the devices are in order. 7. That the coefficients are positive follows from the problem statement. 8. It is very important that the programmer should understand some of the control logic on the interface card. 9. The phenomenon we are going to observe is of great practical importance. 10. The operator could not state the exact moment that phenomenon occurred.

V. Give Russian equivalents for the following:

to be due to, most of, in this way, both... and, nevertheless, in spite of, no matter, at first.

VI. Answer the following questions:

1. How can an e. m. f. be induced? 2. What does the induced current always oppose? 3. What is the change of magnetic flux due to?

4. What do we call self-induction? 5. When will the current in the circuit increase to a steady value determined by Ohm's law? 6. How many turns are there in a coil? 7. What does the current in each turn cause? 8. What generates an emf? 9. What does self-induction oppose? 10. How is the opposing emf generated? 11. When does the lamp glow brightly? 12. When does the lamp become dim? 13. What happens when the switch is open? 14. What will make the lamp glow brightly for an instant?

VII. Be ready to speak about self-induction making use of your answers to the questions.

VIII. Memorize the following terms:

to thread, the loop, to close the switch, flux, self induction.

IX. Translate into English the summary of the text:

Э. д. с. может быть наведена путем изменения числа магнитных силовых линий, проходящих через цепь. Наведенный ток всегда противодействует происходящим изменениям. Показано, как наводится э. д. с. и как она сопротивляется изменению тока, как его увеличению, так и уменьшению. Объясняется, как происходит (возникает) самоиндукция.

21. Condensers and Dielectric Materials

The dielectric of a condenser is one of the three essential parts. It may be found in solid, liquid, or gaseous form or in combinations of these forms in a given condenser.

The simplest form of a condenser consists of two electrodes or plates separated by air, this representing a condenser having a gaseous dielectric. If this imaginary condenser had the air between the plates replaced by a nonconducting liquid, such as transformer oil, and if the distance between the plates were the same as in the first case, the capacitance would be found to have increased several times on account of the oil having a higher value of dielectric constant than air which is usually taken as 1.

The space between the plates being occupied by a solid insulator, a condenser would result, which would be practical, as far as the possibility of constructing it is concerned. It would be found, in this case too, that the capacitance of the condenser was several times larger than when air was the dielectric.

The mechanical construction of either air or liquid dielectric condensers requires the use of a certain amount of solid dielectric for holding the two sets of plates.

There are a great many dielectric or insulating materials available from which one may choose. A material which is very good from the electric standpoint is often found to be poor mechanically or vice versa, air being the gas generally used as a dielectric. Compressed air has been used in some high-voltage condensers, compressed nitrogen and carbon oxide being also in use.

Several kinds of oil have been used in condensers, such as castor oil, cottonseed oil, and transformer oil. More recently electrolytic condensers have come into use in radio equipment for use as filters and by-pass condensers where a large capacitance is required and either a d. c. or pulsating d. c. is applied.

Among the solids to meet the requirements as the condenser dielectric are mica, ceramic materials, and paper. Solid insulators used as mechanical supports in condensers include quartz, glass, porcelain, bakelite, mica, amber, hard rubber, etc.

EXERCISES

I. Read the following words:

nitrogen; oxide; oxygen; hydrogen; iodine; ion — ionize; gas — gaseous; use — useful; close — closely; increase — to increase.

II. Find in the text synonyms for:

shape, to demand, to select, viewpoint, to apply, some, sort.

III. Give Russian equivalents for:

as far as ... is concerned, from the point of view, to be available, on the contrary, vice versa, to meet the requirements.

IV. Find in the text:

a) Constructions with verbals and analyze them;
b) Conditional sentences.

V. Compose sentences with:

on account of, either ... or, from the standpoint, to some degree (extent), vice versa.

VI. Translate into English:

Известно, что металлы являются самыми хорошими проводниками электричества. По сути, все вещества в жидком или твердом состоянии имеют до некоторой степени свойство электрической проводимости. Соли, окислы металлов и другие вещества являются относительно плохими проводниками или изоляторами. Имеется много разных изоляционных материалов. В конденсаторах, например, в качестве изоляторов используется слюда, стекло, сжатый воздух, янтарь, резина и многие другие материалы.

VII. Put questions to the text and answer them.

VIII. Be ready to speak:

a) about the construction of a condenser;
b) about dielectric materials.

22. Some Facts about Magnets

Being heated a magnet loses some or all of its magnetism. A magnet being broken in two, each piece becomes a magnet with its own pair of poles. This subdivision could be carried on until we were down to the smallest particle of iron, a molecule. Conversely, two identical bar magnets being brought end to end with opposite poles in close contact, the poles touching seem to disappear and we have but two poles at the extreme ends. A tube of iron filings may be magnetized by stroking it with a magnet in the usual way. The filings being shaken, the magnetism disappears.

These facts give rise to the very plausible theory of magnetism generally accepted. We know iron molecules to be magnets at all times. When they are arranged in a bar of steel or iron so that the fields of force of all or most of the molecules are in the same direction, their fields are added to one another and the bar is a magnet. The little magnet molecules form chains, their poles disappearing except at the ends of the chain. This condition is not an equilibrium condition because of the like poles in adjacent chains repelling each other. The rigidity of steel holds the molecules in this position. In soft iron, however, as soon as we take the bar out of the magnetizing field, the molecules adjust themselves on account of the repulsions of like poles of molecules in adjacent chains, leaving the iron unmagnetized. We can see why hard steel makes permanent magnets and soft iron does not.

We can also explain why soft iron has a higher permeability than steel. When placed in a magnetic field, the molecules of steel do not readily turn around in the direction of the lines of force. But this alignment is necessary if the body is to absorb lines of force. Heating which increases molecular motion, or jarring causes a magnet to be demagnetized due to its permitting the molecules to adjust themselves to the equilibrium position.

EXERCISES

I. Read the following words and note the pronunciation of *ind, ild, ign, igh:*

k*ind*, gr*ind*, w*ind*, b*ind*; m*ild*, w*ild*; s*ign*, des*ign*, al*ign*, al*ign*ment; s*igh*t, n*igh*t, br*igh*t, l*igh*t, he*igh*t.

II. Translate the following pairs of words, paying attention to the meaning of the prefixes:

division — *sub*division, to appear — to *dis*appear, to impose — to *super*impose; to heat — to *super*heat; to connect — to *dis*connect, to energize—to *de*energize, to magnetize— to *de*magnetize, to change— to *inter*change, to lead — to *mis*lead, to determine — to *pre*determine, to use — to *mis*use.

III. Make up nouns and adjectives from the following verbs and translate all of them:

to except, to arrange, to add, to appear, to magnetize, to permeate, to adjust, to lose, to divide, to align, to accept.

IV. Find in the text antonyms for the following words. Use them in sentences:

to appear, different, to attract, hard, low, to decrease, to acquire, up, likewise, unlike.

V. Learn the following synonymical word groups and expressions. Make up sentences illustrating their use:

conversely, on the contrary; under consideration, in question, at hand, in point; to meet the requirements, to fill the requirements, to meet the demands, to fill the demands; thanks to, due to, owing to, because of, on account of, by virtue of.

VI. Translate the following sentences, noting different meanings of the words in italics:

1. In a condenser *the only* useful characteristic is the capacity. 2. The speed of the molecules is so small compared with that of the electron that *only* a fraction of the current is transformed. 3. *The only* substance which is appreciably diamagnetic is bismuth. All other elements are practically non-magnetic, i. e., their permeability differs from unity *by* less than 1 per cent. 4. *By* the beginning of the 20th century it was clearly demonstrated that the movement of microscopic particles could be explained *only* on the basis of molecular bombardment. 5. *By* the flux density at any point is meant the flux density at any infinitely small surface drawn perpendicularly to the field of the point. 6. The velocity of β rays differs from that of light *by* a few thousandths parts *only*.

VII. Observe the meaning of the word *take* in different combinations. Translate the sentences below:

1. The escape of neutrons from any quantity of uranium is a surface effect depending on the area of the surface, whereas fission action *takes place* throughout the body and is therefore a volume effect. 2. The varying current from the television *takes the place* of the voice currents from the microphone. 3. The discovery of the atomic battery may *take its place* alongside with nuclear reactors in providing the world with new sources of electricity. 4. Many radio amateurs *take advantage* of radio transmitters with one vacuum tube only. 5. Great *care should be taken* in the operation of the mercury-vapor type of rectifier tube to permit the filament to build up a space charge before applying plate voltage. 6. *Care taken* to make nuclear power safe is very great. 7. *It would take* 100 million of small thimble sized atomic batteries to produce enough electricity to light a 100-watt bulb, but

its discovery is a very important one. 8. In atomic power plants special safety *precautions must be taken* to protect the workers from the danger of radioactivity. 9. *It will take* not very much time to see the widespread use of semiconductors in every-day life. 10. In metals conduction *takes place* through the motion of electrons.

VIII. Make a plan of the text.

IX. Retell the text.

X. Write a summary of the text.

XI. Translate into English:

Нагревание магнита приводит к потере им магнетизма. Если разделить магнит на две части, то каждая из них останется магнитом, т. е. каждая часть будет иметь свою пару полюсов. И наоборот, если соединить два магнита, то в результате получится один большой магнит. Общепринятая теория магнетизма легко объясняет ряд очень интересных явлений.

23. Electromagnets and Their Uses

It is easily seen that in a solenoid there is a complete field around each turn. These fields are somewhat modified by the adjacent turns, there being many straight lines coming out from the sides of the coil. Should the coil be wound on a core of soft iron of high permeability, the core would absorb these straight lines and give a concentrated field from one end of the core to the other. We then have an electromagnet. We use soft iron not only because of its having a high permeability, but because its low retentivity allows very little residual magnetism when the current is turned off. The strength of the magnet increases with the number of amperes flowing and also with the number of turns. The product of amperes and turns is called ampere turns. The strength of an electromagnet with a given core is known to be proportional to the number of ampere turns, the strength of the field depending on the shape of the core. If the poles were brought together into a U shape, the field would become stronger. Of course, the two legs of the U must have opposite poles.

The most obvious use of the electromagnet is in lifting iron weights. They are often capable of holding pieces of iron or steel weighing thousands of pounds; they do not slip, as do hooks and ropes; and they can be operated by the throw of a switch at a distance. We know small, powerful electromagnets to be used by doctors to remove steel particles from the eye. Among the common applications of the electromagnet are the electrical bell, the telephone, the telegraph, radio loud-speaker, circuit breakers, relay for remote control of machines, electrical measuring instruments, motors, and generators.

EXERCISES

I. Read the following words, paying attention to the place of the stresses and the pronunciation of the suffixes:

obvious, numerous, various; magnetize, realize, energize; magnify, solidify, intensify; quality, quantity, equality, retentivity, permeability, reliability, accessibility, applicability.

II. Give antonyms for:

to enter, conductor, to finish, retentivity, to turn off, to reduce, to separate, to forbid, powerless.

III. Give the translation of the following words, paying attention to the suffixes and state to what parts of speech they belong:

apply, application, applicable, applicability; allow, allowable, allowance; capable, capability; produce, production, product, productive, productivity; retain, retentivity; magnify, magnification; permit, permission, permissible.

IV. Give examples on the use of the following words and expressions:

by... is meant, in order to, the former, the latter, to be familiar, therefore, no longer.

V. State what part of speech the words in italics belong to and translate the sentences:

1. Our engineers *perfect* different devices. 2. These devices are *perfect* in action. 3. Sometimes a small *amount* of power is quite sufficient for establishing communication over vast distances. 4. The *amount* of energy consumed by this motor *amounts* to that of the engine mentioned above. 5. The *subject* treated above had to do with some innovations achieved in radio engineering. 6. The apparatus used is *subject* to sudden changes of temperature. 7. This *object* has a good reflection surface. 8. Specialists *object* to this material being used as a filament. 9. *Note* that the density of the lines of force is the greatest at the poles. 10. The direction of the magnetic field at any *point* P is arbitrarily chosen as the direction in which a small magnetic needle *point* would *point* when placed at P without disturbing appreciably the existing conditions. 11. No *line* of force crosses another. 12. A freely suspended bar magnet *lines* itself up parallel with the lines of force existing between the north and south magnetic poles of the earth.

VI. Observe the different ways of expressing condition in the following sentences and translate the sentences with the Subjunctive mood:

1. Providing all the requirements were met, the efficiency of the apparatus would be increased. 2. If a natural magnet were suspended by a string from its centre so that it were free to turn, the magnet would be found to turn until the axis through its poles is lying north and south. 3. Had the conductors been moved up and down so as to cut the line of flux of the magnetic field between the poles of the mag-

nets, an e. m. f. would have been generated at the two ends of the conductors. 4. The electric current will flow through a conductor such as a copper wire, if the two ends of the wire are maintained at a difference of potential.

VII. Analyse the different functions of *should* and translate the following sentences:

1. In order to make the necessary observation the current should be passed for about half an hour. 2. We were sure we should be able to overcome all the difficulties in our research. 3. Should the temperature decrease, the velocity of electrons will decrease too. 4. Were the filament heated, we should get the electron emission. 5. It is essential that we should use iron as one of the principal magnetic substances in the case in question.

VIII. Translate the following sentences and observe the different ways of expressing obligation:

1. Where small amounts of power are to be transferred from the generator to the load the condition of maximum power is usually desirable. 2. One ought to know that the electric cell is a device for the transformation of chemical energy into electrical. 3. The electrons in two-element tubes have to go enormous distances before they arrive at the plate with their burden of electricity. 4. It should be pointed out that amplifier tubes act as amplifiers when operated with alternating current on their anodes. 5. When a condenser has an appreciable leakage its resistance must be considered to be in parallel with its e. m. f.

IX. Answer the following questions:

1. What do you know about a field in a solenoid? 2. What would happen, if the core absorbed the straight lines coming out from the sisides of the coil? 3. Why is soft iron used for producing electromagnets? 4. How does the strength of the magnet increase? 5. What is called ampere-turns? 6. What does the strength of the field depend upon? 7. What would take place, if the poles were brought together into U-shape? 8. What is the most obvious use of the electromagnet? 9. What do doctors use electromagnets for? 10. What are the most common applications of the electromagnets?

X. Be ready to talk about electromagnets and their uses.

XI. Translate into English:

Если проводник, образующий замкнутую цепь (closed circuit), движется в магнитном поле так, что он пересекает силовые линии, электроны в проводнике будут двигаться в направлении, которое зависит (1) от направления потока магнитного поля и (2) от направления движения проводника через поле.

Величина э. д. с. в проводнике будет зависеть от числа линий, пересекаемых за единицу времени. То же самое будет наблюдаться, когда проводник неподвижен, а силовые линии пересекают (cut through) проводник.

XII. Memorize the following terms:

line of force, permeability, retentivity, residual magnetizm, core, circuit breaker, remote control.

Part III

ATOMIC THEORY. SEMICONDUCTORS. NUCLEAR ENERGY

24. Rutherford

(From "Reoellections of Lord Rutherford" by Academician P. Kapitsa)

Rutherford created the modern study of radioactivity. He was the first to understand that it is the spontaneous disintegration of the atoms of radioactive elements. He was the first to produce the artificial disintegration of the nucleus and finally he was the first to disoover that the atom has a planetary system.

From research into radioactivity grew up an independent science now called nuclear physics. Both nuclear energy and the use of artificial radioactivity in science and technology are developing quickly and simultaneously. All this for the last thirty years grew out of one modest domain of physics which in the old times was called radioactivity, its father being justly called Rutherford.

There are numerous books and articles on Rutherford as a scientist. Everybody knows the simplicity and clarity of his thinking, his great intuition and great temperament to be very characteristic of his creative ability.

When at the beginning of our century Rutherford started studying radioactivity, these phenomena had already been proved experimentally to contradict the most fundamental law of nature, the law of conservation of energy.

The explanation of radioactivity Rutherford gave, namely the disintegration of matter, at once provided not only the key to the understanding of these phenomena, but also led all investigation in right direction. The same thing happened when Rutherford created the planetary model of the atom.

At first sight this model completely contradicted the laws of classical electrodynamics since in its circular motion an electron was perpetually bound to lose by radiation its kinetic energy. But the experiments of scattering the alpha particles definitely showed the existence of a heavy nucleus in the centre of the atom. Rutherford imagined the collision of particles so clearly that even those contradictions could not prevent him from establishing the planetary structure of the atom.

We know that only three years later N. Bohr, on the basis of developing quantum theory of light, evolved his brilliant theory of the structure of the atom, this not only justifying Rutherford's planetary model but also quantitatively explaining the spectra of atomic radiation.

Rutherford's finest and simplest experiments concerned the phenomena of scattering by nuclear collision. The methods of observation of scintillations by counters were worked out by Rutherford in collaboration with H. Geiger.

The present development of nuclear physics is proceeding not by the invention of new experimental possibilities of investigating nuclear phenomena but thanks to the possibilities of investigating nuclear collisions of a larger number of elements, these collisions being studied in the domain of larger energies reached mainly by the use of powerful modern accelerators. But even now the way leading to the knowledge of the nucleus is still the method discovered by Rutherford, and he was the first to appreciate its fundamental value. Rutherford always liked to say "Smash the atom".

EXERCISES

I. Read the article with due attention being paid to stresses, fluent reading and pronunciation.

II. Analyse the verbals and translate these sentences keeping in mind the rules of translation.

III. Give Russian equivalents for the following:

both... and, namely, at once, the same thing, at first sight, to be bound to, up to now, to be concerned with, other than.

IV. Put the following foreign words into plural:

nucleus, phenomenon, spectrum, axis, radius, focus.

V. Write examples on different meanings of the words and word combinations given below:

paper, last, just as, matter, provided, only, right, since, even, light, about, subject, very, would, development, present, still.

VI. Give all possible synonyms to the following:

finally, quickly, simultaneous, modest, domain, justly, everybody, century, start, fundamental, also, completely, perpetual, basis, briefly, to end.

VII. Give antonyms to:

sufficient, quickly, everybody, simple, at the beginning, right, heavy, never, to end, present, accelerate, always.

VIII. Form all possible derivatives of:

to create, to produce, to cover, to relate, to depend, to investigate, to lead, to complete, to contradict, to move, to exist, to imagine, to evolve, to direct, to argue, to observe, to determine, to add, to possess, to present, to proceed, to accelerate, to know, art, sufficient, simple, able, proof, circle, definite, clear, structure, just, quantity, main, value.

IX. Be ready to ask questions on the text.

X. Write a summary of the acticle.

XI. Choose one of the topics below and be ready to speak on it:

1. The origin of nuclear physics. 2. The planetary model of the atom and the laws of classical electrodynamics. 3. Bohr's theory of the structure of the atom.

25. The Atomic Theory of Matter

A. Let'us speak about the physical properties of matter to-day. In what forms can we divide all substances?

B. According to the physical properties it is convenient to divide all substances into 3 states or forms: solid, liquid and gaseous.

A. May any substances be made to take on any one of these three forms?

B. Yes, most substances may be made to take on any of these forms by altering the temperature.

A. What does the atomic theory of matter assume?

B. The atomic theory of matter assumes all substances in the universe, to be made up of ultra-microscopic bodies called atoms, these being always in a state of rapid motion.

A. What does the nature of this motion of atoms depend upon?

B. The nature of this motion and its activity depend upon the temperature and the state of matter in question, as well as upon the kinds of atoms it is composed of.

A. There are thousands of different substances known to the scientific world, but they all, when broken down into their smallest component parts, are found to be made up of one or more kinds of atoms. Do you know anything about elements, compounds or mixtures?

C. Certainly, we do know that an element is a substance containing atoms of one kind only; while those containing more than one kind are referred to as compounds or mixtures.

A. Give, please, some examples of these kinds of substances.

D. Iron, copper, aluminium, platinum, mercury, hydrogen and helium are examples of elements, water, salt, brass, wood and air being those of compounds or mixtures.

A. What very important property of atoms can you name?

B. One of the most important properties of atoms is their being able to act upon one another at a distance. Some atoms, when close together, can attract each other, while others exhibit a force of repulsion.

A. What may occur when atoms are close together?

C. When, at the close approach of two or more atoms, attraction occurs, the atoms may combine and form a molecule, that will behave as a unit particle under various physical conditions.

A. That's right. What number of atoms may molecules contain?

B. Molecules may contain almost any number of atoms. Molecules having but one atom are called monatomic ones, those with two are known as diatomic molecules. Molecules containing three atoms are referred as triatomic ones.

A. Give some examples of all these kinds of molecules.

D. In the free state of a gas some atoms like helium, neon and krypton prefer to exist alone, while others like hydrogen, nitrogen and oxygen prefer to combine and move about in pairs. In this way: helium (He), neon (Ne), krypton (Kr) are monatomic molecules. Hydrogen (H_2), nitrogen (N_2), oxygen (O_2) and carbon monoxide are diatomic molecules. Triatomic molecules are ozone (O_3), carbon dioxide (CO_2), water (H_2O) and hydro-cyanic acid (HCN).

EXERCISES

I. Read the following words:

oxide, dioxide, monoxide; oxygen, hydrogen, nitrogen; universe, uniform, unidirectional, unilateral; develop, contain, important, component.

II. Give derivatives of the following words and translate them:

atom, to assume, to act, to move, to differ, to contain, to repel, to behave, to exist, to prefer, to occur, to attract, to vary.

III. Give as many synonyms as you know for:

substance, rapid, although, to occur, whereas, to call, important, like, under consideration, only, to exert a force, nearly.

IV. Make up sentences, using the following words and word combinations:

to deal with, in question, as well as, to be composed of, to exhibit a force, in general.

V. Give all the meanings you know of the words *but*, *once*, illustrating them in sentences.

VI. Translate the following sentences, paying attention to the translation of the words in italics:

1. The change of the flux is *certainly* produced by a change of current. If two circuits are coupled to a *certain* extent by two coils in a *certain* position with respect to one another and another coil is added in series with one of these, the coefficient of coupling of the two circuits has been lessened. 2. Though the molecules and the atoms are so small the scientists are quite *certain* of their existence. 3. The structure of the atom of nearly every substance is now known with a remarkable degree of *certainty*. 4. The increase in the temperature *means* the change in the rate of the electron movement. 5. The *mean* velocity of the electron movement is indicated by a special device. 6. By the watt *is meant* the energy expended per second by an unvarying electric current of one ampere under the pressure of one volt. 7. Iron is *by all means* the most important metal, not alone because of its comparative cheapness, but because of the high value of the permeability in most electric apparatus. 8. If one electron is removed from the atom *by some means* or other, the balance between positive and negative charge is destroyed. 9. *By no means* can this device be put into operation.

VII. Make up a plan of the text.

VIII. Be ready to speak about the atomic theory of matter according to your plan.

IX. Translate this summary into English:

В этой статье обсуждаются физические свойства веществ. Рассматривается атомная теория материи. Допущено, что вся материя состоит из атомов. Найдено, что атомы находятся в состоянии постоянного (непрерывного) движения. Будучи близко друг к другу, атомы могут соединяться и образовывать молекулы. Даются примеры разных типов молекул.

26. The Atom and the Electron

Present atomic theories, based on the atom model, place the mass and positive charge of an atom in a central nucleus, surrounded by moving electrons. The nucleus is composed of neutrons and protons. Neutrons have a mass approximately one-sixteenth that of the mass of the oxygen atom and have zero electrical charge. They occur in fixed numbers in all nuclei except that of hydrogen H^1. The proton has a mass slightly lighter than that of the neutron and approximately equal to the mass of the hydrogen atom H^1. It has a charge equal to that of the electron but positive in sign. The chemical elements are differentiated by varying numbers of protons and neutrons in the nucleus, the number of protons being equal to the atomic number, hydrogen having one, helium two, and so on. Since the atom is in electrical balance in its normal state, the number of associated electrons moving around the nucleus is equal to the number of protons.

The electron is the smallest known indivisible unit of electric charge. Early experimenters succeeded in measuring the ratio of the charge of the electron to its mass, and in 1910 the charge was first measured, thus determining these properties of the electron. Repeated experiments have defined the values for these constants of the electron, and they are now believed to be

Charge = e = 1.602×10^{-19} coulomb

Mass = m = 9.106×10^{-31} kg

Charge/unit mass = $\frac{e}{m} = 1{,}759 \times 10^{11}$ coulomb/kg.

The electron appears to have a dual personality[16], at times being best thought of as a particle, and in other experiments seeming to require wave properties for a satisfactory explanation of the phenomena.

Electric current is due to movement of electric charges, frequently referred to as electrons. However, long before the existence of the electron was known, it was customary to speak of electric current as due to movement of positive charges from positive to negative in a metallic circuit external to the source. *This usage is too well established to be readily overcome*[17], even though it is now known to be reversed, with the negative electrons moving from negative to positive in the external metallic circuit. Therefore, when electric currents are discussed, the customary direction will be meant; when reference is made to electronic current, then the flow of electrons is being considered.

EXERCISES

I. Read the following words and their derivatives; translate these words:

theory, theoretical, theoretician; equal, equality, to equalize, equalization, equation; to associate, association; experiment, experimenter, experimental, experimentation; to relate, relation, relationship, relative, relatively; to satisfy, satisfaction, satisfactory, satisfactorily; to refer, reference; to succeed, successful, successfully, successive, succession; to differ, different, difference, to differentiate, differentiation; approximate, approximately, proximity, approximation.

II. Give as many English equivalents as you know for:

состоять из, происходить, кроме, количество, так как, определять, требовать, часто, легко, предполагать.

III. Give antonyms for the following words, illustrating their use in sentences:

heavy, divisible, late, to fail, seldom, internal.

IV. Make up sentences, using the following words and word combinations:

to succeed in, to fail, to be due to, by... is meant, reference is made to, except.

V. Be ready to answer the following questions:

1. What is the nucleus of the atom surrounded by? 2. What is the nucleus composed of? 3. What mass have neutrons and what is their electrical charge equal to? 4. What can you tell about the mass of the proton and its charge? 5. How are the chemical elements differentiated? 6. What is the number of protons equal to? 7. When is the atom said to be in electrical balance? 8. What is the electron? 9. What do you know about "the dual personality" of the electron? 10. What is electric current due to?

VI. Retell the text.

VII. Translate into English:

Этот текст описывает строение атома. Его ядро состоит из протонов и нейтронов. Оно окружено движущимися электронами. Протоны являются положительно заряженными частицами. Нейтроны имеют нулевой заряд. Электроны же, наоборот,— отрицательно заряженные частицы. Если число протонов в атоме равно числу электронов в нем, то говорят, что атом находится в электрическом равновесии.

27. Radioisotopes

Hydrogen comes in three isotopes, their atomic weights being one, two and three. They are set apart by writing the mass number after the chemical symbol for hydrogen. Thus, H-1 refers to the lightest of all atoms, the light isotope of hydrogen — protium. H-2 (deuterium) designates heavy hydrogen. The only other isotope of hydrogen is known to be a radioactive form called tritium or H-3. To be precise we should call this a radioisotope, but the use of the term "isotope" is ordinary.

There are 280 stable, naturally-occurring isotopes, together with 73 natural radioisotopes. In addition, man has added 960 artificial radioisotopes to nature's store.

Each radioisotope is known to have its own distinct nuclear personality. This is revealed in the rate at which the atoms of the particular isotope disintegrate, as well as by the kind of radiation or rays given off by the disintegration. As a matter of fact the term "half-life" is used to describe the rate at which some radioactive material loses its radioactivity. It is the time required for a radioactive substance to be reduced to 50 per sent of its original radioactivity.

For example, radium-226 has a half-life of 1,600 years. If we start today with a fresh sample of radium-226, then in 1,600 years half of this will have disintegrated, so that we have on hand only half as much as we had originally. Tritium, another example, has a half-life of $12^1/_4$ years. A very slowdecaying or long-lived isotope is U-238 with its half-life of $4^1/_2$ billion years. Some radioisotopes, on the other hand, are extremely short-lived, chiefly disappearing in times measured in tiny fractions of a second.

We know different kinds of rays to be emitted by radioisotopes. U-238 throws off a heavy, slow-moving particle called the alpha particle. Cobalt-60 emits powerful gamma rays (similar to X rays) which can penetrate inches of solid lead. Tritium gives off very weak beta rays which are absorbed in such thin films of matter that one has to use a Geiger counter for their detection.

The disposition of the atoms —as displayed by its half-life and its radiation — makes possible a wide application of isotopes to industry, agriculture, biology and space research.

EXERCISES

I. Read the following words with the proper pronunciation:

isotope, isolate, hydrogen, nitrogen, weigh, weight; nature, natural, naturally; sample, example.

II. Find in the text synonyms for:

to be referred to as, usual, accurate, speed, shape, man-made, to apply, to demand, to decrease, initially, to decay, very small, various, substance, like, to show, to investigate.

III. Memorize the following word combinations:

in addition to; as well as; as a matter of fact; on the other hand; thus.

IV. Find in the text antonyms for:

heavy, unusual, to finish, rapid, to appear, powerless, strong, liquid, narrow, long-lived.

V. Give the different meanings of:

only — the only; very — the very; one; for.

VI. Memorize the following words of the same stem:

to apply, application, applicable; to add, addition, additional; to reduce, reduction; to lose, loss; to measure, the measure, measurement.

VII. Find in the text sentences with:

1. Nominative Absolute Construction; 2. Complex Subject with the Infinitive; 3. Complex Object with the Infinitive.

Translate these sentences in the proper way.

VIII. Pay attention to the meaning of the verbs and phrasal verbs in italics; translate the sentences below:

1. Since Ohm's Law *holds good* for maximum values it also *holds good* for average values when the current and voltage wave forms are similiar. 2. The form of the current can be so arranged that the field is negligible in strength although it can never *be done with* absolutely. 3. In fact the voltage stress produced by the wave can be considered as *resulting from* the movement of the magnetic flux of the same wave. 4. When the current changes, the field also changes, and thus the conductor is cut by its own lines of force *resulting in* a self-induced e. m. f. proportional to the change of linkages per second. 5. The addition of the grid to a gas-filled diode *results in a* tube which has found unusually wide application in electrical, communication, control systems and power circuits. 6. The question of setting a unit of e. m. f. *can be dealt with* in the same way as for current. 7. The iconoscope mosaic *may be thought* of as a two-dimensional array of tiny photoelectric cells, each shunted by a condenser which couples it to a common signal load. 8. A simple rule for determining the relative directions of current and flux *makes use of* the right hand, the fingers being curved as though grasping the wires carrying the current, and the thumb being outstretched. 9. Much work has been done in attempting to explain terrestrial magnetism and *to account for* its variations. 10. An electron about to leave the metal induces a positive charge on the surface behind it and hence is attracted backward toward the metal. This action *gives rise to* the idea of the potential barrier, somewhat like surface tension, which must be overcome before the electron can escape. 11. Proper fluctuations in the intensity of the luminescent spot are *brought about* by applying the video signal to the grid of the electron gun. 12. In carbon an increase in temperature *brings about* a decrease in resistance.

IX. Retell the text.

28. Concept of "Solid"

Materials that may be regarded as solids can generally be divided into two categories, amorphous and crystalline. In amorphous substances, the atoms or molecules may be bound quite strongly to one another, but *there is little, if* *any, geometric regularity*[18] or periodicity in the way in which the atoms are arranged in space. Such substances can be regarded as supercooled liquids. A two-dimensional representation of an amorphous material is shown in Fig. 3.

Crystalline substances, on the other hand, are characterized by a perfect (or nearly perfect) periodicity of atomic structure, this regularity of structure providing a very simple picture and simplifying the understanding and calculating of its crystal properties. For this reason, crystalline solids are better understood physically than amorphous solids or liquids. Sometimes the presence of a relatively small num-

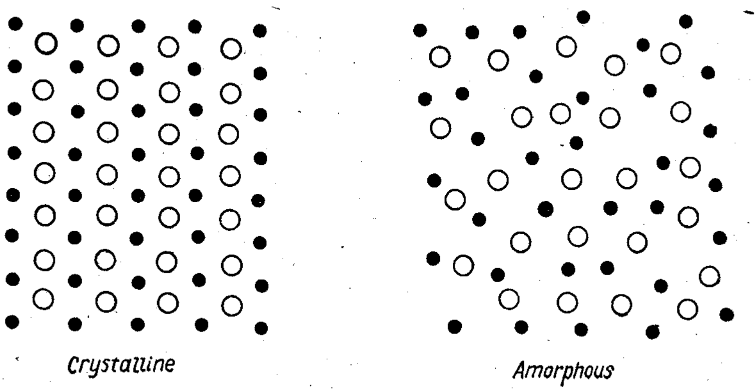

Fig. 3

ber of imperfections in an otherwise perfectly periodic crystal may cause striking changes in the physical behaviour of the material.

Finally, it should be realized that macroscopic samples of crystalline solids such as metals, ceramics, ionic salts, etc., are not always single crystals, being often composed of an array or agglomerate of small single crystal sections of various crystal orientations separated from one another by "grain boundaries".

EXERCISES

I. Read the following words with the proper stress:

characterize, simplicity, perfect, relative, otherwise, realize; amorphous, arrange, change; regularity, periodicity, supercooled, supersonic; two-dimensional, macroscopic; agglomerate, estimate, separate, orientate.

II. Read and translate the following words paying attention to the prefixes *super, under, macro, micro:*

*super*heated, *under*cooled, *super*cooled, *super*sonic, *under*estimate, *under*go, *under*graduate, *macro*scopic, *macro*circuit, *micro*scope, *micro*wave, *micro*phone, *micro*relay.

III. Make up all possible words of the same stem and translate them:

to divide, strong, to arrange, period, regular, relate, to provide, perfect.

IV. Find in the text synonyms for:

to consider, usually, to count, at last, to understand, different, to connect.

V. Find in the text antonyms for:

multiplied, crystalline, weak, solid, perfection, numerous.

VI. Answer the following questions:

1. How can solids be divided? 2. How are the atoms or molecules bound in amorphous substances? 3. Is there any regularity of periodicity between them? 4. What substances can be regarded as supercooled ones? 5. What is characteristic of crystalline substances? 6. Why are crystalline substances better understood physically? 7. What may cause changes in the physical behaviour of the material? 8. What do macroscopic samples of crystalline solids consist of?

VII. Be ready to speak about solids.

VIII. Describe a two-dimensional representation of an amorphous material as shown in Fig. 3.

29. Semiconductors

A review of the mechanism for conducting electricity through various kinds of matter shows that in electrolytes and in gases conduction occurs through the motion of ions, that in metals conduction takes place through the motion of electrons, and that in insulators there is no conduction but only a slight displacement of the charges within the atoms themselves. There is still another kind of matter in which conduction takes place by electrons just as in metals, but, contrary to the behaviour of metals, a substance of this kind exhibits an increase of resistance as the temperature falls. Such a substance is referred to as a semiconductor, and at the absolute zero of temperature it would be an insulator. Among the examples of semiconductors the most important at present seem to be silicon and germanium.

The variation of resistance with temperature is accounted for as follows. In a metal only a very few electrons are free to move upon application of a potential difference. The temperature of the metal being lowered, the thermal vibration of its atoms is reduced; as a result the atoms interfere less with the motion of the electrons, and consequently the resistance is lowered. Those electrons free to move in a metal are in semiconductors bound loosely to the atoms. At absolute zero a semiconductor has no current carriers. The temperature being raised, more and more of the loosely bound electrons are released by the thermal energy and conduction is improved, which means that the resistance is lowered as the temperature rises.

The current carriers in a semiconductor may be supplied by an impurity. For example, an arsenic impurity in silicon supplies one loosely bound excess electron for each atom of arsenic dissolved, and hence conduction is due to a transfer of excess electrons; such a semiconductor is said to be of the n-type, because of the carriers being negative. In contrast a trace of boron in silicon removes one electron for each atom of boron dissolved, and the «hole» left in the electronic structure of a silicon atom provides a type of conduction, called hole or deficit conduction, by transfer from atom to atom of electrons into available holes. A semiconductor in which the conduction is due to holes is said to be of p-type, because of the carriers acting like positive charges, for the «hole» travels in a direction opposite to that of the electrons filling it.

The importance of semiconductors, at least in present application, arises from their behaviour when in contact with a metal. When the two substances are placed in contact, the free electrons in the metal and those in the semiconductor come into equilibrium. Their numbers being unequal, and the forces that bind them being unequal too, there is a transfer of electrons, which continues until the charge accumulated is large enough to repel a further transfer of electrons. The accumulation of charge at the interface acts as barrier layer, so-called due to its interfering with the passage of current.

The barrier at the interface between conductor and semiconductor is decreased when potential is applied in one direction and is increased when potential is applied in the opposite direction. Hence, the current will rise sharply with increase of potenital in one direction, called the «forward» direction, but will remain small with increase of potential in the other direction.

EXERCISES

I. Read the following words:

a) with the stress on the first syllable: substance, follow, carrier, contrast, opposite, barrier, passage, value, utilize, consequently;

b) with the stress on the second syllable: review, within, occur, exhibit, behaviour, explain, electron, improve, remove, impurity, excess, available, importance, accumulate.

II. Pay attention to the correct pronunciation of the following words:

through, exhibit, themselves, dissolve, available, interface, interfere, unidirectional.

III. Find in the text sentences with:

a) Complex with the Gerund.

b) Complex Subject with the Infinitive.

IV. Find in the text English equivalents for the following expressions and memorize them:

в противоположность, в настоящее время, в результате, вследствие, следовательно, по крайней мере.

V. Translate and memorize the following terms:

to resist, resistance, resistivity, impurity, arsenic, hole, interface, layer, silicon.

VI. Make a written translation of the third passage of the text, beginning with: "The current carriers in a semiconductor..."

VII. Compose a short dialogue on semiconductors.

VIII. Describe: a) how conduction occurs in conductors and semiconductors; b) explain the variation of resistance with temperature; c) tell about the importance of semiconductors and their applications.

IX. Write some questions and answers about semiconductors.

X. Translate this summary into English:

В этой статье показан механизм электрической проводимости в разных веществах. Определяются также свойства полупроводников. Обсуждается зависимость сопротивления от температуры. Даются примеры разных типов полупроводников.

30. The Band Structure of Semiconductors and Metals

Semiconductors differ from insulators only in the width of the forbidden band. In the band structure of silicon, for example, the stable atomic spacing occurs very close to the crossover point, and hence the forbidden band is quite narrow (about 1.1 ev in silicon, and about 0.72 in germanium). We may consider silicon to be an insulator with a narrow forbidden band. The crystal is classed as a semiconductor because at room temperature there are enough electrons excited across the forbidden gap to make both the electron and hole concentration in the conductor and valence bands, respectively, large enough to cause appreciable conductivity. The resistivity of silicon at room temperature is about 3.000 ohm-m, and that of germanium about 0,6 ohm-m.

In the case of silicon and germanium, both electrons and holes contribute to the conductivity, the holes in each case contributing about half as much as electrons because of their lower mobility. Copper, which has $(1S)^2$, $(2S)^2$, $(2P)^6$, $(3D)^{10}$, and $(4S)'$ electrons, will be a good conductor because the 3D and 4S bands overlap, the 4S band being only half filled. There is an abundance of energy states available for the electrons to assume as they move through the crystal. This factor, combined with the large number of electrons available, makes copper one of the best conductors available.

In summary, while it is possible to predict that certain materials will or will not be conductors from their band structure and the way, the bands fill with electrons, *certain caution must be exerted*[19]. It is correct, for example, that the alkali elements which have an S band half filtered are metallic in nature. Also the noble gases which have filled bands, should in the solid form be insulators. Sodium chloride acts like potassium chloride because of its being also an insulator. Then we find the elements like Be, Mg, Ca, Sr, and Ba, however, which have two S electrodes and would be expected to be insulators. They are of course metals. This effect must be explained by the presence of a P band directly above S band which overlaps it in energy.

EXERCISES

I. Read the following words:

resistivity, conductivity, mobility; contribute, distribute; appreciable, available; caution, overlap, overestimate, to predict.

II. Read fluently:

differ only in the width, very close to the crossover point, excited across the forbidden gap, in the conduction and valence band, the holes in each case contribute, about half as much as the electrons, combined with the large number of electrons available.

III. Write out of the text the special terms pertaining to the structure of semiconductors and metals and learn them.

IV. Memorize and translate the following adjectives with the suffix *-able*:

apprec*iable*, avail*able*, reason*able*, consider*able*, suit*able*, measur*able*, compar*able*.

V. Make up nouns from the following adjectives:

wide, strong, long; pure, inpure; available, stable, similar, resistive.

VI. Make up derivatives from the following words:

to assume, to consider, to appreciate, to add, to resist, to conduct, to contribute.

VII. Pick up pairs of synonyms from the following words:

to differ, for instance, to indicate, to take place, to assume, as, appreciable, on account of, to change, to occur, for example, because, to show, because of, considerable, to suppose.

VIII. Give the different meanings of *state, above, case, make* and illustrate them in sentences.

IX. Find in the text the antonyms for the following words:

lower, half-empty, irrespective of, wrong, under.

X. Put questions to the text.

XI. Be ready to speak about the band structure in semiconductors and metals.

XII. Write a summary of the text.

31. Practical Semiconductors

Photons, Phonons, Electrons and Holes

In order to explain adequately the properties of practical semiconductors the group of particles characterized by its comparative freedom of motion and composed of photons, phonons, electrons, and holes must be considered.

The electron is known to have both particle and wavelike properties, interacting with the lattice and with other electrons and holes. It also interacts with photons and phonons. This has been made clear by the fact of energy in the form of radiation being given off and absorbed by the electron when it changes energy state. This radiation is quantized according to Planck's theory of radiation.

The photon, which is an electromagnetic vibration, may be considered to have both wavelike and particlelike properties. It can carry energy from point to point in the crystal as can a moving particle. It collides with other particles and with the lattice. It moves with the speed of light and has a very temporary existence between the time it is radiated and reabsorbed. The photon is absorbed, and its energy used up in lifting an electron from the valence band into the conduction band. As is evident, this process creates a free electron and a free hole. Each may contribute to conduction. The reverse process may occur as well. The free electron which drops down to fill a hole will give off a photon, the conduction caused by the excitation process being usually called photoconductivity, photons being in fact radiated and absorbed in electron transitions within the bands. There is a constant interchange of energy between the electrons and the photons.

There is a second particlelike wave which may interact with the electrons and the lattice. It is called a phonon. The lattice may be thought of as a mechanical system of masses and springs, the phonon being a mechanical vibration of this lattice and it is quantized first like a photon. It carries energy from point to point in the lattice and may, like the photon, give up its energy to cause a transition. The accoustical waves travel with the speed of sound in the solid. In fact, the usual frequency range for phonons is from ordinary sound frequencies up into the frequency range which corresponds to the infra-red for photons.

If a solid is in thermal equilibrium, the photons, phonons, electrons, and holes will all be in equilibrium with each other and with the lattice, there being a constant interchange of energy between the various particles and the lattice. Consider as an example a solid heated to incandescence. The solid being heated, its phonons become more and more energetic, until finally the photons which are in thermal equilibrium with the phonons are energetic enough to be visible. At the same time some electrons become energetic enough to escape from the solid, and thermionic emission takes place.

EXERCISES

I. Read the following words:

adequate, separate, accurate; characterize; energize, quantize; lattice, practice, notice.

II. Read fluently:

in order to explain adequately, both particle and wavelike properties, with the lattice and with other electrons, this radiation is quantized accordingly, it collides with other particles, a very temporary existence, it may contribute to conduction, a constant interchange of energy, just like a photon.

III. Form nouns from the following verbs and underline the suffixes:

to explain, to compare, to exist, to absorb, to consider, to move, to conduct, to emit, to vary, to cause, to excite, to contribute.

IV. Find in the text synonyms for:

movement, shape, velocity, to apply, obvious, to take place, also, commonly, to name, permanent, different, at last, sufficiently.

V. Find in the text antonyms for:

to give off, to drop, direct, unusual, liquid, the same, cooled.

VI. Memorize the following words and word combinations:

in order to, according to, as well, to take place.

Illustrate their use in sentences.

VII. Answer the following questions:

1. What properties has the electron? 2. What does the electron interact with? 3. What form of energy does the electron give off and absorb? 4. What properties has the photon? 5. How is the energy of the photon used up? 6. What does this process create? 7. What is called photoconductivity? 8. What is called a phonon? 9. What properties has the phonon? 10. In what state are the photons, phonons, electrons and holes if a solid is in equilibrium? 11. What takes place between the various particles and the lattice?

VIII. Be ready to speak about:

1) photons; 2) phonons; 3) electrons; 4) holes.

32. Intrinsic and Extrinsic Semiconductors

Intrinsic Semiconductors. Suppose the energy gap between the filled band and the conduction band of an insulator to be very small. In that case the substance will be a good insulator at low temperatures, but at sufficiently high temperatures the crystal will start to conduct. The reason is that because of the interaction between the electrons in the filled band and the lattice vibrations, some may gain enough energy to be transferred from the valence band into the conduction band. The conductivity is found to increase very strongly with increasing temperature.

Conductors that have this property are called **intrinsic semiconductors,** the name "intrinsic" implying that the semiconducting property is a property characteristic for the pure material. In cases in which the semiconducting property of the material is due to impurities, the semiconductors are called **extrinsic semiconductors.**

Another characteristic of intrinsic semiconductors is that the current is carried by two types of carriers.

One type is of course the electrons in the conduction band. But for every electron in the conduction band an electron must be missing from the valence band. Such a vacant spot in the valence band is called a hole. It acts in many respects as a positive charge, is mobile and thus takes part in the conduction process.

In intrinsic semiconductors the current is found to be carried by two types of carriers, electrons and holes. In many respects it would be much more convenient to have semiconductors with only one type of carrier, either electrons or holes. Semiconductors in which the current is carried predominantly by holes are called p-type semiconductors (p-for positive). The current being carried predominantly by electrons, the semiconductor is said to be n-type (n-for negative).

Ionic crystals can be made into n-type or p-type semiconductors by introducing slight deviations from stoichiometry, such substances being called excess or defect semiconductors.

Valence band crystals can be made into both n-type and p-type semiconductors by adding impurities, these being called impurity semiconductors.

N-Type Semiconductors. Consider a semiconductor having the valence band completely filled and the conduction band completely empty, and having in addition occupied energy levels slightly below the bottom of the conduction band. One then has to increase the temperature very slightly in order to raise the electrons bound to those occupied levels into the conduction band. For that reason these levels are called donor levels.

P-Type Semiconductors. Consider a semiconductor having the valence band completely filled and the conduction band completely empty and having in addition unoccupied energy levels slightly above the top of the valance band. One then has only to raise electrons from the valence band to these unoccupied energy levels to leave free holes behind in the valence band. These unoccupied energy levels are called acceptor levels.

EXERCISES

I. Read the following words:

valence, vacant, pure, purity, impurity; defect, excess, intrinsic, extrinsic; to transfer, transfer; to increase, increase; to imply, to supply; predominantly.

II. Translate and memorize the following words:

pure, purity, impurity; act, action, interaction; reason, reasonable; add, addition, additional; consider, consideration, considerable; to conduct, conduction, conductivity; to bind, bond.

III. Memorize the following pairs of synonyms:

vacant — empty; below — under; sufficiently — enough; reason — cause; substance — matter; completely — entirely; to raise — to lift.

IV. Write examples illustrating the different meanings of *one, but, that, only.*

V. Find in the text antonyms for the following words:

below, top, to decrease, occupied, inconvenient, empty, appreciate, negative.

VI. Memorize the following special terms:

conduction band, intrinsic semiconductor, extrinsic semiconductor, excess semiconductor, impurity, carrier, bond, energy level, top (bottom) of the band.

VII. Put questions to the text.

VIII. Retell the text according to the plan given below:

1. Intrinsic semiconductors. 2. Extrinsic semiconductors. 3. Excess or defect semiconductors. 4. Donor levels. 5. Acceptor levels.

IX. Write a summary of the text.

33. General Classification of Crystal Types

It is possible to classify crystals in many ways, for example, according to crystal lattice, electrical properties, mechanical properties, or chemical characteristics. For the purpose at hand, however, it is most convenient to adopt a scheme of classification based on the type of interaction responsible for holding the atoms of the crystal together. Solids are known generally to fall into one of four categories: ionic, covalent, metallic or molecular, each of these four classes, in turn, being not absolutely distinct. Some crystals may at the same time possess characteristics associated with more than one of these general classes.

I o n i c c r y s t a l s are crystals in which valence electrons are transferred from one atom to another, the final result being a crystal composed of positive and negative ions. The source of cohesive energy that binds the crystals together is the electrostatic interaction between the ions. The electronic configuration of the ions is essentially an inert gas configuration, the charge distribution of each ion being spherically symmetric. Ionic crystals usually have relatively high binding energies, and as a result, fairly high melting and boiling points. They are quite poor electrical conductors at normal temperatures and are usually transparent to visible light, while exhibiting a single characteristic optical reflection peak in the far infra-red region of the spectrum. The crystals are often quite soluble in ionizing solvents such as water, the solutions being highly dissociated into free ions.

C o v a l e n t   c r y s t a l s are crystals in which valence electrons are shared equally between neighboring atoms rather than being transferred from one atom to another as in ionic crystals. There is thus no net charge associated with any atom of the crystal. A typical example of a covalent atom is diamond, in which each carbon atom shares its four valence electrons with its four nearest neighbors, forming covalent electron-pair bonds. These electron-pair covalent bonds in a diamond are the same as the covalent carbon-to-carbon linkage which is found so frequently in organic compounds. They are strongly directional in character, that is, the electrons tend to be concentrated along the lines joining the adjacent atoms. Covalent crystals are usually hard, brittle materials with quite high binding energies and thus high melting and boiling points. They are typically semiconductors, whose electrical conductivity is quite sensitive to the presence of tiny amounts of impurity atoms, and increases with rising temperatures at sufficiently high temperatures. They are transparent to long-wavelength radiation but opaque to shorter wavelengths, the transition being abrupt and occurring at a characteristic wavelength, usually in the visible or near infra-red.

The metallic elements in the free state form m e t a l l i c   c r y s t a l s in which free electrons are present. The presence of these free electrons accounts for the very high electrical and thermal conductivity of metals. The high electrical conductivity is in turn directly responsible for high optical reflection and absorption coefficients that are the most characteristic optical properties of metals. The binding energy of "ideal" metals, such as the alkali metals, arises from the interaction of the free electron gas with the positive ions of the lattice, although for many other metals the picture is more complicated. The actual binding energies of metallic crystals may be quite low, as for alkali metals, which have relatively low melting and boiling points, or quite high as in the case of tungsten, whose melting point is very high indeed.

M o l e c u l a r c r y s t a l s are crystals in which the binding between the atoms and molecules is neither ionic nor covalent, but arises solely from dipolar forces between the atoms or molecules of the crystal. The binding forces arising from fluctuating dipole interactions are called Van der Waals forces, these forces being usually quite weak. Molecular crystals are thus characterized by small binding energy and consequently low melting and boiling points. They are usually poor electrical conductors. Crystals of organic compounds are usually of this type, as are the inert gases He, Ne, A, etc., in the solid state.

EXERCISES

I. Read the following words with the proper stress:

classify, amplify, rectify, magnify; relative, sensitive; adopt, attain, attend; distinct, distribute, disperse, distinguish; distribution, configuration; ion, ionic, ionize; possess; associate.

II. Find in the text the following grammar constructions:

1. Complex Subject with the Infinitive.
2. Nominative Absolute Participle Construction.
3. Elliptical Sentences.
4. Different forms of Participles.

III. Find in the text synonyms for:

for instance, aim, in question, simultaneously, enough, commonly, often, to link, very small, quantity, to explain, complex, though, due to, strength, therefore, to consist of.

IV. Translate the following pairs of antonyms and memorize them:

transparent — opaque; purity — impurity; directly — indirectly; vacant — empty; conductivity — resistivity; high — low; top — bottom; complicated — simple.

V. Memorize the following word combinations and give examples for their application:

at hand, generally, in turn, as a result, such as, rather than, thus, that is, indeed, neither... nor, consequently.

VI. Translate and memorize the following special terms:

crystal lattice, cohesive energy, charge distribution, infra-red region, net charge, electron-pair covalent bond, carbon-to-carbon linkage, binding energy, dipole interaction.

VII. Mind the different meanings of *as, but, for*.

VIII. Write words of the same stem and translate them:
possible, responsible, final, to transfer, to act, to relate, to solve, equal, direct, to link.

IX. Put questions to the text.

X. Retell the text.

XI. Be ready to speak on the following topics:
1. The classification of crystals. 2. Ionic crystals. 3. Covalent crystals. 4. Metallic crystals. 5. Molecular crystals.

XII. Write a summary of the text.

34. Crystal Growing

For transistor or diode fabrication one must use single crystals with controlled amounts of impurity. Crystals are grown by touching a seed crystal to the surface of liquid semiconductor material and slowly withdrawing it as new lattice layers form by freezing out of the melt. A typical crystal-growing furnace is shown in Fig. 4.

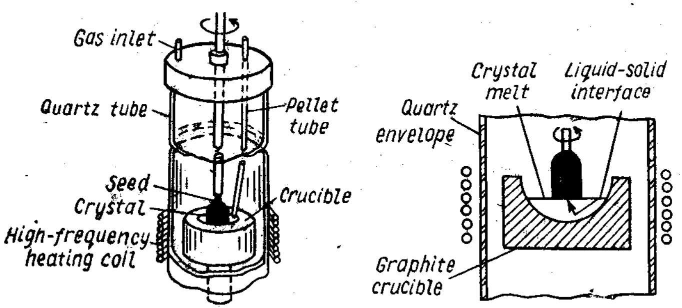

Fig. 4

The limitation of this system is that the impurity concentration increases as more melt is used up. This is due to impurities tending to remain in solution. The impurity concentration, either desirable, or undesirable, tends to increase as the volume of the melt decreases. The bottom of the crystal may have ten times the impurity concentration of the top.

An improved type of crystal-growing furnace has a rod of polycrystalline germanium feeding into the melt, with the correct impurity concentration to keep the over-all concentration in the melt at the correct value. In fact this method is found to hold a constant resistivity throughout the length of the grown crystal. The seed is usually rotated at about one revolution per second, the temperature of the melt being used to control the diameter of the crystal (usually about 2 cm).

Although certain chemical impurities are introduced in a preplanned manner, it is essential for future processing that undesirable impurities be controlled. Special techniques are used to reduce the impurities introduced from the crucible which holds the melt, for example. Dislocations in the semiconductor interfere with future processing, an excess of these dislocations giving inferior operating characteristics. *If the seed crystal is "necked down" to a small diameter*[20] before expanding to a single large crystal, dislocations may be minimized.

A change in growth rate or in the degree of mixing the liquid changes the solute content in the freezing solid. If the impurity or solute is a donor or acceptor, the conductivity changes. We see that this dependence of the crystal structure on the method of growth makes possible the formation of junctions during the growing process. Again, the processes used in modern semiconductor growing techniques are numerous.

EXERCISES

I. Read the following words with the proper stress and pronunciation:

furnace, preface, menace; move, improve; to process — process; to progress — progress; to subject — subject; to content — content.

II. Read fluently:

to the surface of liquid semiconductor material; a crystal-growing furnace; with the correct impurity concentration; throughout the length of the growing crystal; in a preplanned manner; to reduce the impurities introduced; interfere with future processing; inferior operating characteristics; the solute content in the freezing solid.

III. Find in the text the following grammar forms and give their proper translation:

1. The Complex Subject with the Infinitive.
2. The Nominative Absolute Construction.
3. Subjunctive Mood.

IV. Find in the text antonyms for:

rapidly, old, solid, to decrease, the top, wrong, lack, to contract, desirable, superior.

V. Find in the texf synonyms for:

quantity, to indicate, to keep, permanent, to revolve, to decrease, particular, speed, to alter, to apply.

VI. Translate the following words of the same stem:

to dissolve, solvent, solute, solution, soluble, insoluble; pure, purity, impurity; revolve, revolution; to desire, desirable, undesirable.

VII. Translate and memorize the following terms:

solute, solution, melt, bottom, crucible, junction, freezing out; solute content; lattice layer; impurity concentration; overall concentration; seed crystal; crystal growing furnace; semiconductor growing technique.

VIII. Answer the following questions:

1. What kind of crystals must be used for transistor or diode fabrication? 2. How are crystals grown? 3. How does the impurity concentration depend on the volume of the melt? 4. What do you know about the improved type of the crystal growing? 5. What is obtained as a result of this method? 6. How is the seed usually rotated? 7. What is essential for future processing in order to control the undesirable impurities? 8. What is the cause of inferior operating conditions in semiconductors? 9. What makes possible the formation of junctions during the growing process?

IX. Describe a typical crystal-growing furnace as shown in Fig. 4.

35. Preparation of Germanium and Silicon

There are some methods to prepare germanium and silicon for use in transistors and diodes. The raw materials must be purified to a very high degree. Special processes for refining the materials are used which have been perfected only in recent years. Finally, single crystals are grown in one of several convenient ways. The demand for pure semiconductor materials has given great impetus to improvements in metallurgical processes.

Germanium is the most widely used semiconductor at the present time because of its being relatively easier to purify than silicon. Even in the case of germanium, however, it is extremely arduous to obtain material of the necessary purity. Germanium ores are very rare. Zink ore found at great depths contains several hundredths per cent germanium. Ores such as zink have too low a concentration of germanium.

The reduction to germanium metal or germanium dioxide is carried out under conditions of great cleanliness. Equipment used is of quartz or special plastic, ovens being non-metallic. Germanium dioxide may be processed to germanium metal by reduction at temperatures of 650 to 1100° C in a controlled atmosphere. A process called segregation can be used on this metal for further purification. The ingot obtained in the previous procedure is melted in a graphite boat at 1030° C and then subjected to directional cooling. The impurities tend to remain in the liquid phase and will be swept to the end which freezes last. A more elaborate procedure of this sort is used in the final purification and growing of crystals of both germanium and silicon.

Silicon has two very desirable properties, due to which it has a much brighter future in the semiconductor field than germanium. It is the most abundant solid element on earth and has favorable semiconductor characteristics up to about 200° C in contrast to germanium, *which is extremely rare in nature and fails as a semiconductor at temperatures above 100° C*[21]. The disadvantage lies in its purification, which is extremely difficult and therefore expensive. Silicon is obtained from quartz or silica. This Sio_2 will react with carbon at high temperatures to produce silicon and carbon dioxide. The silicon carries many impurities with it (other metals). If chlorine is introduced into this process, silicon tetrachloride is produced. This product can be reduced to relatively high-grade silicon.

To further purify silicon, the crystals are reacted with iodine fractionally distilled and subjected to a decomposition process in a quartz tube at about 900° C, producing iodine crystals and purer silicon crystals. After the chemical purification is complete, a zone-refining process must be used to reduce the impurities to 1 part in 10 billion or less.

Zone-refining may be with both silicon and germanium. It consists of passing a molten region down a long rodlike ingot of the semiconductor to be purified. The process by which purification takes place is called impurity segregation. Most impurity atoms prefer to remain in the liquid phase of the ingot and hence as the liquid-solid interface passes down the bar, it pushes the impurities ahead of it. The end of the bar to solidify last contains a higher percentage than normal of the impurities and may be cut off. This process may be repeated five to ten times, passing several molten zones down the bar in a single pass.

EXERCISES

I. Read the following words:

purify, purification; necessary, necessity, necessitate; obtain, obtainable; desire, desirable; favourable; to process, process; subject, to subject; elaborate, communicate, procedure.

II. Make up nouns from the following words:

pure, to reduce, clean, fail, introduce.

III. Add the prefix *dis-* and translate the words formed of:

advantage, location, regard, appear, connect.

IV. Add the prefix *re-* to the following words:

act, fine, combine, turn, store, heat.

V. Give examples illustrating the different meanings of:

time, as.

VI. Answer the following questions:

1. What semiconductor materials are the most widely used in transistors and diodes? 2. What process must the raw materials be subjected to? 3. What has the demand for pure semiconductor materials given a great impetus to? 4. Why is germanium the most widely used semiconductor at present? 5. What ore contains several hundredths per cent germanium? 6. Under what conditions is the reduction to germanium metal or germanium dioxide carried out? 7. How may germanium dioxide be processed? 8. What does the process called segregation consist in? 9. What two properties has silicon? 10. What are the advantages and disadvantages of silicon? 11. What is silicon obtained from? 12. How is silicon tetrachloride produced? 13. How can silicon be further purified? 14. What does zone-refining consist in?

VII. Be ready to speak about:

1. Germanium and methods of processing it. 2. Silicon and methods of processing it. 3. The zone-refining process.

VIII. Translate the following terms and memorize them:

Чистый, чистота, очищать, очистка, примесь, печь, контактная поверхность, примесные атомы.

IX. Translate into English:

Имеется несколько методов приготовления германия и кремния для их использования в транзисторах и диодах. Сырье должно быть тщательно очищено. Германий широко применяется в полупроводниковых приборах. Его сравнительно легче очистить, чем кремний. Но руды германия очень редки. Кремний находится в очень больших количествах. Но очистка его чрезвычайно трудна и дорога.

36. Basic Transistor Physics

A. You know that both the transistor and the vacuum tube are amplifying devices. Who can tell me what is the amplifying effect in these devices based on?

B. The amplifying effect in a vacuum tube is known to be based on the control of an electron flow in a vacuum. In a transistor the flow of the charged carriers is controlled in a solid-state semiconductor body.

A. That's right. What is the operation of transistors based on?

B. The operation of transistors is based on the properties of semiconductors. Semiconductors are the elements and compounds whose electric properties lie between those of conductors (in which many free electrons are necessary for electric current flow) and insulators (in which free electrons practically do not exist).

A. Do conductors and insulators change their properties under external influences such as temperature, light or magnetic field?

B. No, they don't. For example, the electrical resistivity of a metal changes only slightly with temperature. Only in the vicinity of 0° K does an abrupt change take place.

A. And what about semiconductors?

B. This stability is not true of semiconductors. For example, if the temperature changes some ten degrees centigrade, the electrical resistivity of pure germanium changes several hundred times.

A. That's right I see you have an idea about the basic transistor physics.

EXERCISES

I. Read fluently:

the control of an electron flow, the flow of the charged carriers, under external influences, to change the properties, the electrical resistivity of a metal, in the vicinity of 0° K, ten degrees centigrade.

II. Give different meanings of the following words and illustrate their use in sentences:

for, as, state, do, some, times, degree.

III. Make up sentences using the following expressions:

for example, to take place, in the vicinity of, to be true of.

IV. Find in the text participles and analyse them.

V. Write some questions to the text and answer them.

VI. Be ready to speak on:

1. The transistor and the vacuum tube as amplifying devices. 2. The operation of transistors. 3. The effect of external influence on conductors and insulators. 4. The stability of semiconductors.

VII. Learn the parts of A and B.

VIII. Translate into English:

Известно, что как вакуумные лампы, так и транзисторы используются в качестве усиливающих приборов. Действие вакуумных ламп основано на управлении потоком электронов в вакууме. Свойства проводников чрезвычайно важны для работы транзисторов. При изменениях внешних воздействий таких, как свет, температура, электрические свойства проводников и изоляторов меняются лишь незначительно. Например, изменение температуры очень мало влияет на электрическую сопротивляемость металла и наоборот. В полупроводниках изменение температуры на несколько десятков градусов меняет электрическую сопротивляемость германия в несколько сот раз.

37. Transistors, the Basic Mechanism

Transistor action is the control of currents or voltages in one junction by the currents or voltages in another junction. This control is possible because of the minority and majority carriers flowing across the junctions being controllable. Transistor action can occur when we have two or more rectifying junctions in close proximity. In fact, all transistors make use of rectification at junctions within materials in one way or another.

There is a large variety of transistorlike devices, some examples being the transistor diode, which may be of the alloy, surface-barrier, grown-junction, melt-quench, diffused-base, drift, or point-contact types. There are tetrode transistors, field-effect transistors, spacistors, and many more. It seems likely that there will soon be at least as many transistors types as there are vacuum tubes types.

All transistors have some features in common. They are generally small in size. The actual working volume of a transistor seldom exceeds a cubic millimeter. This is true even for high-power devices. There is a heat-dissipation problem to be faced in almost all transistor applications. In high-power applications, particularly, the heat-dissipating structure is many times the size of the device itself. The characteristics of transistors depend upon the operating temperature to a great extent, and special consideration must be given to the stability of transistor circuits as a function of temperature. The power dissipated in circuits will be large enough to cause large changes in the temperature of the transistor. In the case of the vacuum tube, temperature is not usually a primary circuit stability consideration since the tube is usually hot anyway because of the use of thermionic cathodes. As an aid in solving the temperature-sensitivity problem, new high-temperature materials are being developed. Germanium is good for the devices operating below about 90° C. Silicon can be used to about 200° C. There is no reason to believe that better materials cannot be developed.

EXERCISES

I. Read the following words:

1) with the stress on the first syllable:
rectify, amplify, liquify, purify, simplify; utilize, synthesize, realize, recognize, synchronize;

2) with the stress before the suffixes *-ity, -ic:*
proximity, variety, majority, minority, possibility, flexibility, simplicity, stability; atomic, synthetic, electronic;

3) with the correct pronunciation of the suffix *-able:*
controllable, suitable, available, reasonable, applicable, stable.

II. Find in the text antonyms for:

frequently, uncontrollable, far, unlikely, small, cold, secondary.

III. Find in the text synonyms for:

to take place, to use, instrument, dimension, nearly, especially, under, degree, to take advantage of.

IV. Give the different meanings of the following words and illustrate them in sentences:

close, time, since.

V. Translate the following sentences paying attention to the word combinations:

1. *There is every reason to believe* that if the voltage gradient is made sufficiently high, every atom can be forced to let go one electron, and such is the case. 2. *There are reasons for believing* that in a body of gas about all of the molecules have velocities very close to the average. 3. It should be noted that the relationship expressed by Ohm's Law *holds true* for metallic conductors under the condition that the potential difference is maintained constant. 4. *To the same extent* as we can show the existence of positive charge inside a vacuum tube, we know that *to just the same extent*, the gas which has supposedly been removed by the evacuation process is still present. 5. The β rays ionize gases but show this properly *to a much less extent* than the α rays.

VI. Put questions to the text.

VII. Be ready to speak on the topics given below:

1. Transistor action. 2. The common features of all transistors. 3. The characteristic of transistors. 4. The temperature sensitivity of the transistors in vacuum tubes and transistors.

VIII. Memorize the following terms:

minority carriers, majority carriers, surface-barrier, junction transistor, grown-junction transistor, melt-quench, drift, point-contact, field-effect transistors, spacistor, air.

38. The Structure of the Triode Transistor

The triode transistor itself takes several distinct forms. There are point-contact transistors and junction transistors.

The point-contact transistor consists of two point-contact diodes which are very close together. The current in either diode will have an important effect upon the current in the other diode. It is possible by biasing the diodes properly, to obtain power amplification of electric signals, the spacing between the points being only a few mils. The contacts are applied to a carefully treated surface. One of the points is designated as the emitter and biased in the forward direction, the other as the collector and biased in the reverse direction. The third contact is a large-area contact usually plated to the back of the polished or sandblasted base. Power amplification is obtained by virtue of the fact that the variation in the emitter current causes as large or larger variation in the collector current.

A device which is more stable both mechanically and electrically can be constructed by forming junctions rather than point contacts. The junction transistor consists of two p—n junctions on opposite sides of a thin slab of semiconductor crystal. The most common low-frequency transistor is probably the alloy type. The collector junction is made larger than the emitter junction to improve the collector action.

A pair of closely spaced p—n junctions may be grown in a bar of semiconductor crystal as the crystal is pulled. Transistors formed in this manner are known as grown-junction transistors. A series of n and p regions may be formed by changing the chemical composition of the melt or by changing the rate of crystal formation. The crystal containing the junctions is then cut into bars. Contacts are made to the ends and to the base region. The above mentioned processes may be used to form either n—p—n or p—n—p transistors. The p—n—p transistor is most easily made by grown-junction method.

The existence of two types of transistors, the n—p—n and p—n—p, offers an unusual amount of flexibility in circuit design.

EXERCISES

I. Read fluently:

by biasing the diode properly, to a carefully treated surface, biased in the forward direction, to the back of the sandblasted base, by virtue of the fact, as large or larger variations, by forming junctions rather than contacts, by changing the chemical composition, the above mentioned processes, an unusual amount of flexibility.

II. Translate the following words of the same stem and word combinations with them:

flexible, flexibility; minor, minority, minority carrier; major, majority, majority carrier; proper, properly, property; care, carefully, direct, forward direction, reverse direction.

III. Translate the following sentences paying attention to the translation of the words in italics:

1. *By virtue* of the fact that it combines so readily with oxygen, sodium is always kept under some liquid that does not contain that element. 2. There is some evidence that cosmic rays are made up of charged particles *rather than* of protons. 3. In making actual measurements the resistance of the solution *rather than* the conductance is measured. 4. It is sometimes noticed that if a comparatively weak north pole be brought in the vicinity of a strong north pole, attraction between the two poles results, *rather than* the repulsion which might be expected.

IV. Put questions to the text.

V. Be ready to speak about:

1. Different forms of transistors. 2. The point-contact transistor, its construction and properties. 3. The junction transistor, its construction and properties. 4. The grown-junction transistor, its construction and properties.

VI. Write a summary of the text.

39. "The Death Ray" Is no Longer Science Fiction

The so-called "death rays" have had a long history in fact and in fiction.

They became an actuality in the 1890's when Nicola Tesla, in his high-frequency experiments used electric energy beams — without wires — over distances of several miles. He transmitted electric power wirelessly over appreciable distances.

In his "War of the Worlds" H. G. Wells had his earth invading Martians use a lethal heat ray *to keep human armies at bay*[22]. Hardly any science-fiction author *could do without his pet death ray*[23] after the early 20's. These lethal rays were usually electric such as "condensed lightning" and many others.

As far back as the early 50's[24] the great power of radar beams was demonstrated.

Many experiments were carried out with the fabulous Maser (microwave amplification by stimulated emission of radiation) and Laser (light amplification by stimulated emission of radiation). A recent breakthrough in both can turn radio into light energy (or power), or light into radio energy.

In some experiments, a light (Laser) beam cut a steel razor blade in two. Other scientists burned holes through stainless steel sheets.

That laser action lasted only 1/2,000 second. But that was only a microbeginning. Because laser beams are non-spreading and tight, it became possible to project a series of beams onto the moon with comparatively small energy (2,000 Joules).

This was comparable to the power of a 2,000,000 watt lamp.

EXERCISES

I. Read the text paying due attention to stresses and pronunciation (no translation).

II. Give Russian equivalents for the following:

no longer, to keep at bay, hardly to do without, the early 20's, such as, as far back as, to turn into, a series of.

III. Memorize the synonymical pairs:

actuality — reality, several — some, pet — favourite, usually — ordinarily, recent — latest, to turn into — to transform into, because — as, a series — a set of.

IV. Answer the following questions:

1. What was meant by "death rays"? 2. Have these so-called "death rays" a long history? 1. When did they become an actuality? 4. What did Martians in H. G. Well's novel "War of the Worlds" use to keep human armies at bay? 5. Did any other science-fiction authors use "death rays" in their writings? 6. What kinds of rays were those "death rays"? 7. When was the great power of radar beams demonstrated? 8. What is meant by a "Maser"? 9. What is meant by a "Laser"? 10. What were the first experiments with masers and lasers? 11. How long did that laser action last? 10. Give some examples of uses of "death rays».

V. Retell the text «"The Death Rays" Is No Longer Science Fiction».

40. Introducing the Laser

Quantum Generators

In recent years a highly important trend in science, quantum electronics, has been developing rapidly. This science was born in 1952, when a new method was proposed for generating and amplifying radio waves by the use of quantum micro systems — molecules, atoms and so on.

This method has proved to be very fruitful and has produced results that by far transcend the scope of conventional radio engineering.

The path to optical radio on the basis of radio-frequency quantum generators clocks have been made that measure time with an accuracy of one second per 3,000 years. Modern scientific achievements make possible the manufacture of clocks which measure time with an even higher accuracy of one second per tens of thousands of years.

These super-precise generators are of greatest importance as without such generators spaceships for example cannot be guided accurately to other planets.

Of no less importance are the quantum amplifiers that considerably increase the sensitivity of radio receivers, and this considerable increase in sensitivity opens up great vistas for radar, radio navigation, space radio communications, radio astronomy, and other fields of science and technology.

Now quantum electronics has enabled man to penetrate into the realm of invisible.

Light and radio waves are known to be of the same nature. They represent electromagnetic oscillations which only differ in wavelength.

What the Laser Is

The laser for all its revolutionary properties actually stems from another development several years old. As you may have noticed there is a similarity between the words "laser" and "maser", and the similarity is more than a coincidence. A laser is simply a maser capable of operating at frequencies within the visible light range.

In spite of its tremendous promise, the laser is an extremely simple-looking device. It is nothing more than a cylinder of synthetic ruby about $^{1}/_{4}''$ in diameter and $1^{1}/_{2}''$ long, mounted in the center of a spiral coil of glass. The coil is a xenonfilled flash tube, very much like the ones used by photographers for taking flash pictures. A jolt of current is sent through the glass filled tube, setting off a brilliant flash of greenish light. The electrons in the ruby absorb this light and generate energy at another frequency. To put it another way, the ruby absorbs[25] greenish light, only to give off a pure red ray. And the beam produced by this atomic flashlight is capable of performing the feats mentioned earlier — as well as a number of others — because it is unique in several important ways.

"Coherent" Light

The light generated by the laser is coherent. This means that all its rays are at one frequency. Natural light, in contrast, whether produced by the sun, a light bulb, or a match, is made up of rays of different colours, or frequencies.

Fantastic amounts of information can be picked into one light beam. With such a system we may some day transmit thousands of television signals and hundreds of thousands of telephone, teletype, and telegraph signals on a single laser beam.

In addition, the laser, by operating in visible light spectrum, vastly increases the number of useful frequencies we can put to work.

The coherence of laser light is responsible for another useful property: it makes the laser beam far narrower than any previously available.

As is the case with most new developments[26], no one knows for sure in how many new ways the laser will turn out to be useful.

But there will undoubtedly be many as yet undreamed applications for this newest wonder child in the field of electronics.

EXERCISES

I. Find in the text sentences with asyndetic subordination, state the kinds of Subordinate Clauses and translate these sentences.

II. Add:

a) suffixes: *-ish, -ful* or *-less* to the following adjectives and nouns:

green, red, yellow, black, pink, power, wonder, use;

b) prefixes: *im-, in-, ir-, il-, un-, under-, super-* or *over-* to the following words:

possible, visible, regular, legal, known, look, estimate, high, parallel.

III. Make up sentences illustrating different meanings of the following words and word combinations:

one, very, only, but, for, kind, development, since, field, current, much, like, light, even, about, amount, space, much, rest, state, still, well.

IV. Memorize the following expressions and give their Russian equivalents:

and so on, back and forth, one way, over a distance, a number of, a few, as well, 1000 times more, to make use of, in spite of, it is nothing more, to put it another way, as well as, as is the case, some day, for sure, as yet, the fact that, in a way, on the one hand, on the other hand, for a while.

V. Arrange the following words in synonymical pairs:

instantly, precise, propose, at once, accurate, simultaneously, exact, actually, offer, at the same time, really, like, complete, similar, entire, due to, to raise, because of, to increase, immediately.

VI. Pick up antonymical pairs out of the words given below:

never, narrow, similar, early, upper, unlike, lower, ever, broad, late, always, to reduce, inside, complicated, to increase, outside, simple.

VII. Mind the difference between:

beside — besides; between — among; little — a little; near — nearby; hard — hardly; most — the most; because — because of; to turn on, to turn off, to turn out, in turn; such as—as such; the least—at least; to give — to give up; to build — to build up.

VIII. Form derivatives from:

intence, to accomplish, to amplify, certain, product, able, include, similar, coincide, to operate, absorb, pure, collide, to perform, mean, nature, to contain, to compare, complete, effect, transmit, doubt, to depend, to remain, to add, to extend, to emit, to represent, to excite, to measure.

IX. Mind the prepositions used in the following:

for the first time, in contrast with, in the same way, in one jump, to be responsible for, for sure, at a frequency, to depend on (upon).

X. Be ready to ask questions on the text.

XI. Be ready to speak on the topics below:

1. The experiment mentioned in the article. 2. What a maser is. 3. The difference between a maser and a laser. 4. Coherent light.

XII. Memorize the following terms:

radio-frequency generators, super-precise generators, sensitivity, space radio communication, wave length, ruby, flashlight.

41. Semiconductor Laser

Soviet scientists are successfully developing quantum generators called lasers for emitting light-amplitude radio waves. These lasers use luminescent crystals, for example, the crystals of synthetic ruby luminescent glass, a mixture of various gases and finally semiconductors.

The Lebedyev Institute of Physics developed a laser on the basis of a gallium arsenide semiconductor. A group of the Institute scientists were awarded a Lenin prize for this work.

Semiconductor quantum generators occupy a special place among the optical quantum generators. The size of a ruby-crystal laser comes to tenths of a centimeter while a gas generator is about a meter long.

A semiconductor laser is a few tenths of a millimetre long, whereas the density of its radiation for volume is hundreds of thousands of times as great as that of the best ruby laser. Semiconductor lasers operate under pulse and permanent regimes. It is very easy to control the generator oscillations to "modulate" its radiation by simply changing its field current.

Perhaps the most interesting thing about semiconductor lasers is that they can transform electrical energy directly into light-wave energy. They do this with an efficiency approaching one hundred per cent as compared with a maximum of about 1 per cent of other lasers.

Semiconductor lasers open up great vistas for solving various scientific and technical problems. Calculations and experiments show that already super-hard substances (diamonds, rubies, etc.) and hard alloys can be worked profitably by ruby lasers, for example.

The development of powerful, highly efficient semiconductor lasers will considerably raise the power efficiency of a number of technological processes.

The high-frequency radiation of optical generators makes it possible to transmit an enormous flow of information. This is of great significance for the advancement of communication techniques. The small dimensions of the semiconductor laser make it especially suitable in superspeed computers.

The high efficiency of semiconductor lasers opens up possibilities of developing extremely economical sources of light.

EXERCISES

I. Read the following words paying attention to stresses and pronunciation:

mixture, suitable, negligible, luminescent, efficiency, enormous, award, occupy.

II. Pick up synonyms out of the following list of words:

to call, to produce, to utilize, example, different, special, whereas, instance, various, to generate, to name, use, while, particular, perhaps, transform, settle, raise, maybe, turn into, increase, significance, rate, advancement, importance, development, speed, size.

III. Make up sentences using the following words and word combinations:

finally, to be awarded, as great as, compared with, to solve a problem.

IV. Form derivatives from:

emit, generate, mix, dense, simple, oscillate, direct, consider, mean, extreme, efficient.

V. Give different meanings of the following words, illustrating these meanings in sentences:

hard, about, under, very, only, over, most, a number, development, like, close.

VI. Mind the difference between English and Russian:
as great as, a meter long, makes it possible.

VII. Pick up out of the text all terms referring to semiconductor lasers and learn those terms by heart.

VIII. Answer the following questions:

1. What is a laser? 2. What is it developed for? 3. What do these lasers use? 4. What kind of a laser did the Lebedyev Institute of Physics develop? 5. What was a group of the Institute's workers awarded a Lenin prize for? 6. What place do semiconductor quantum generators occupy among the optical quantum generators? 7. What is the size of a ruby generator? 8. What is the density of radiation of a semiconductor generator? 9. Under what regime do semiconductor lasers operate?

IX. Retell the text.

X. Translate into English:

Полупроводниковые квантовые генераторы занимают особое место среди оптических квантовых генераторов. Так называемый «лазер», разработанный в Институте физики имени Лебедева, имеет длину в несколько десятых миллиметра. Полупроводниковый лазер может преобразовать электрическую энергию прямо в световую. Малый размер лазера особенно важен для сверхскоростных вычислительных машин.

42. Nuclear Energy

Great quantities of energy are imprisoned in the nuclei of atoms. Some of this energy may be liberated by the fusion of hydrogen to form helium or by the fission of heavy atoms such as uranium and thorium. Formerly the liberation of nuclear energy in paying quantities seemed nearly hopeless. Alpha particles were expensive and millions of them were required to break up even one atom.

The discovery of the neutron in 1932 stimulated nuclear research and uranium was bombarded with neutrons. The scientists hoped to produce new elements of atomic number greater than 92. They got evidence of new atoms, but found them difficult to identify. Finally, in 1939 it was realized what was happening. Instead of producing heavier atoms, the neutrons appeared to be splitting (fissioning) uranium atoms into unequal parts. Neutrons can fission heavy atoms.

The news excited the physicists very much. It was partly because they hoped to tap the energy of the nucleus. Einstein's equation $E = mc^2$ told them that the splitting of heavy atoms should liberate energy. They hoped that the process might be self-sustaining. It might be a chain reaction. That is, an atom, split by one neutron, might supply neutrons to split neighbouring atoms. Soon it was proved that ordinary uranium of mass number 238 can be "triggered" by fast neutrons having energies of many electron-volts. The rare isotope uranium-235 can be split more easily by slow neutrons having energies of a few hundredths of an electron-volt.

Each ton of uranium contains only 17 pounds of the rare uranium-235 isotope. The effort to separate enough rare uranium for the Hiroshima (Hiroshe'ma) atomic bomb required five years and two billion dollars. Thousands of physicists, chemists, and engineers did the job.

43. Machines for Producing High-Energy Particles

In most ion accelerators developed for nuclear research, the individual particle having a charge Q appears to be accelerated through a potential difference V, and thus its energy is increased by the amount VQ. The acceleration may be applied in a single step, as in a voltage-multiplier apparatus, or it may be applied in repeated smaller steps of lower potential difference, thereby reducing the hazards and insulation problems. The effect of the acceleration is to increase the kinetic energy of the particle, at first by increasing its speed. But for electrons even at low energy and for heavier particles such as protons at higher energies, the speed soon approximates that of light, whereupon the supplying of additional energy increases the relativistic mass of the particle. For this very reason the high energy machines are more properly called ponderators than accelerators.

The electron is not suitable for causing nuclear disintegration because of its being of relatively large size. The particle usually chosen is the proton, although the deuteron (the nucleus of heavy hydrogen, of mass number 2) is often used, the alpha particle being less frequently employed.

The Electrostatic Generator. The electrostatic generator gives a steady beam of ions accelerated through a potential difference which can be controlled to within a fraction of one per cent. Such a monoenergetic beam of electrons or protons is valuable for accurate quantitative work; for example, in scattering experiments. Million-volt electron generators are now available commercially for industrial X-rays work. A 3.5-Mev machine was built to inject protons into the proton synchrotron and generators of about 12 Mev are being constructed for use in nuclear research.

The Proton Synchrotron. The limit on particle energies that can be reached with the cyclotron is set by the size of magnet required to produce a uniform field across the chamber in which the particles are accelerated. The magnet of the cyclotron contains 3700 tons of steel and 300 tons of copper, its power requirements being correspondingly large. Still higher particle energies are needed, however, in order to study the nature of the forces acting within the nucleus energies estimated to be of the order of a billion electron-volts. This objective can be attained by accelerating protons in a so-called proton synchrotron.

Protons are now being accelerated in these high energies by the proton synchrotron. It consists of a vacuum chamber having four curved portions with straight segments between them. In one straight section, monoenergetic protons are injected by an electrostatic generator. These fast-moving particles follow the desired path in the evacuated tube on account of the action of magnets which surround it, their coils being energized by a motor-generator to give the correct magnetic flux density for the particular particle speed at any instant. The group of protons passing through the fourth straight section, it is accelerated by an applied r. f. electric field, somewhat as in the cyclotron and linear accelerator. The protons continue to go around in the chamber, gaining energy each time they pass this accelerating section.

The Betatron. A machine for accelerating electrons to very high speeds is named the betatron after beta rays, which are ejected from radioactive substances at comparable speeds. The machine is used chiefly for producing X rays of great penetrating power. It consists of an evacuated doughnut-shaped glass tube placed between the poles N and S of a powerful electromagnet which is energized by alternating current in the circular coils. An electron gun is arranged to project the electrons tangentially into the tube. Here they are acted upon by two forces: a radially inward force that makes them follow the curvature of the tube, and a tangential force that gives them higher speeds.

The electrons are first projected into the tube for a few microseconds just as the magnetic field starts to build up, they move at increasing speed around the tube, and finally at a chosen instant they are deflected from their circular path to the X-ray target. All this occurs within a quarter of a cycle, before the field has reached its maximum value; nevertheless, the electrons travel around the tube many thousands of times during this period. In succeeding cycles these operations are repeated over and over again.

A limitation predicted theoretically and proved experimentally in betatron operation is that the electrons at such high speeds lose energy by radiation because of their centripetal acceleration. Hence to achieve higher energies, paths of larger radius should be used, and these involve a larger and heavier magnet; further, there should be fewer revolutions between the injection of electrons and the end of their path at the target.

EXERCISES

I. Read fluently:

repeated smaller steps of lower potential difference, the effect of the acceleration, the kinetic energy of the particle, the supplying of additional energy, the relativistic mass of the particle, because of its being of relatively large size, controlled to within a fraction of one per cent, such a monoenergetic beam of electrons, the proton synchrotron and generators of about 12 Mev., it consists of a vacuum chamber.

II. Pick up antonymical pairs out of the following list of words:

to accelerate, to increase, single, high, at first, heavy, straight, fast, finally, to slow down, multiple, light, to decelerate, to speed up, to reduce, low, at last, curved, to gain, initially, slow, to lose.

III. Translate the following words:

to prove, proof, waterproof, fireproof, foolproof; to involve, involved; proper, properly, property; to approximate, approximation, approximately, proximity; to suit, suitable, suitably, suitability; value, valuable, invaluable, to evaluate, evaluation; to contain, container, content; to correspond, correspondence; to compare, comparison, comparative, comparatively, comparable, incomparable; to succeed (in), success, successful, successfully, successive, successively.

IV. Translate the following sentences, paying attention to the meaning of the words in italics:

1. *Under proper conditions* the above method will give the best results. 2. The method *proper* being quite new, the equipment used was thoroughly tested. 3. Tested *under proper conditions* the device *proper* was found to give accurate readings. 4. If *properly* designed, the meter should give correct readings. 5. The *property* of absorbing lines of force is called magnetic permeability. 6. We have discussed the symptoms caused by the defects in the "a. g. c." system *proper*.

V. Retell the text "Nuclear Energy".

VI. State the functions of the Infinitives in the text "Machines for producing high-energy particles".

VII. Make up a plan of the text "Machines for producing high-energy particles" and retell the text according to your plan.

VIII. Give a description of the Proton Synchrotron.

IX. Put 6 questions to the part "Betatron" and answer them.

X. Write a summary of the whole text.

XI. Translate and memorize the following technical terms:

fission, fusion, ponderator, beam, target, voltage multiplier, flux density.

44. Uranium-235 as an Explosive

Not long after the discovery of fission it became evident that, if a sufficient quantity of pure uranium-235 (U-235) could be isolated from its more abundant isotope uranium-238 (U-238) it might have explosive powers many times greater than anything heretofore known. The reasons for believing this appeared at the time to be somewhat as follows. Suppose a given mass of uranium metal, all composed of U-235 atoms, to have been brought together into one lump. The first cosmic ray that penetrated this mass and produced a neutron might well set off the chain reaction shown schematically in Fig. 5. A U-235 nucleus would capture the neutron and in splitting apart with great violence liberate one or more additional neutrons. These in turn would be quickly absorbed by other nearby atoms which in turn would split up and at the same time liberate other neutrons. Hence a rapidly growing kind of avalanche might occur, a kind which, if fast enough, would have the characteristics of an explosion.

The escape of neutrons from any quantity of uranium is a surface effect depending on the area of the surface fission capture occurring throughout the body and being therefore a volume effect. Should the assembled mass of uranium be too small the probability that most neutrons liberated by fission would escape through the surface before being captured might well be so large that a growing chain reaction could not occur. The volume of a sphere increasing with the cube of the radius while the surface area increases with the square of the radius, the probability of escape would decrease with increasing size. In other words, if the uranium mass were too small the growth process would be cut off before it became very large and only if the mass were greater than some critical value would an explosion take place.

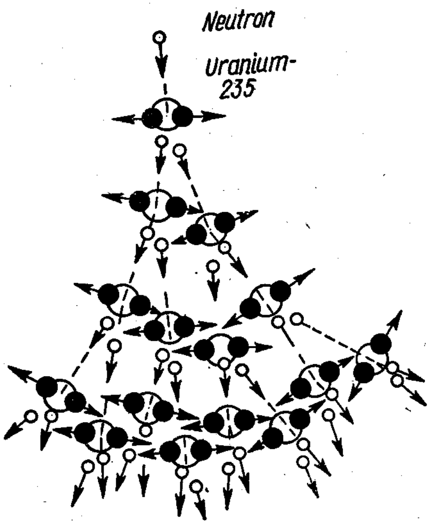

Fig. 5

Visualize therefore a large quantity of U-235 in units smaller than the critical size, separated either by distance or by neutron absorbing material like cadmium metal. Suddenly by some mechanical process all is made as one single mass considerably greater than the critical value. A few neutrons created within this system should set off the chain reaction resulting in explosion.

EXERCISES

I. Give as many synonyms as you know for:

to occur, fast, enough, value, to result in, somewhat, hence, heretofore, reason, to believe, to be composed of, to produce, to show, to set free, simultaneously, throughout, dimension.

II. Give antonyms for the following words and use them in sentences:

pure, to capture, to increase, after, to disappear.

III. Write derivatives from the following words and translate them:

to discover, evident, to suffice, abundant, to explode, to appear, violent, to add, to depend upon, to consider, to create.

IV. Make up sentences, using the following word combinations:

there is every reason to believe, in its turn, depending on, either... or, neither... nor, both... and; to result in.

V. Give different meanings of the words: *too, well, but, for.* Give somer examples of their use.

VI. Put some questions to the text and be ready to answer them.

VII. Describe the chain reaction shown schematically in Fig. 5.

45. The Uranium Pile

The uranium pile is a kind of atomic furnace in which U-235 is the "fuel burned" and many useful atomic by-products are produced. A schematic diagram of a pile constructed of solid carbon blocks surrounded by thick absorbing walls of concrete is shown in the accompanying Figure. Long cylindrical holes through the carbon blocks provided space for the insertion of all materials and controls needed for proper operation. Chemically pure uranium in tightly sealed aluminum containers is inserted in alternate rows of blocks, water flowing through pipes to keep the temperature of the entire mass from rising dangerously high.

When within the uranium metal a few U-235 atoms undergo fission, fast neutrons are liberated. Entering the surrounding medium, these neutrons collide frequently (about every 2.5 cm) with carbon atom and are slowed down. Eventually entering uranium metal again as slow neutrons, some are captured by U-235 nuclei to produce fission and hence more neutrons. Each fission producing several neutrons, the total number in the pile will increase continuously and the temperature will rise from the recoiling energy of the carbon atoms. The whole process proves to be a selfsustaining chain reaction only if a sufficient number of the neutrons produced find their way into U-235 nuclei before being lost or absorbed by some other process.

The other processes referred to are: (1) absorption by U-238 nuclei to produce U-239, (2) absorption by carbon atoms, (3) absorption by impurities, and (4) loss by escape through the furnace walls. The first of these, if not too large, is a desirable process as it leads to the production of Pu-239. The second appears to be small since carbon is used as furnace material in preference to so many other substances because

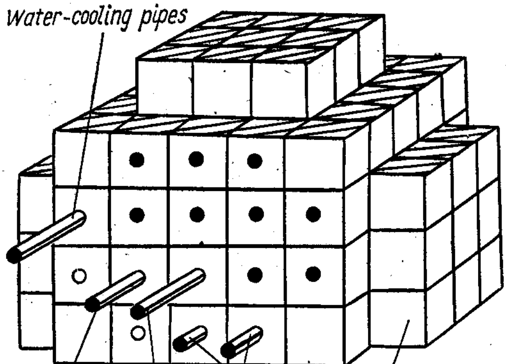

Fig. 6

of its relatively low neutron capture probability. Small quantities of impurities initially present, as well as those resulting as fission fragments, are unavoidably present. The fourth loss is minimized by making the pile sufficiently large, thereby increasing the volume-to-wall-area ratio.

Due to cadmium atoms being strong absorbers of neutrons a solid cadmium rod inserted into the pile will absorb many neutrons and, acting as a damper, limit the neutron density as well as the temperature within the pile. Activity within the pile is measured with a boron trifluoride counter inserted through one of the holes.

After many hours running, the uranium samples are removed and chemical separation processes are carried out to segregate the various products. The unused uranium is separated out to be used again, while the plutonium and other elements, all highly radioactive, are used for numerous other experiments. Such large quantities of radioactive elements are produced in the pile that all handling and chemical processing must be carried on by remote control methods. The dangers to operators will be realized when it is pointed out that one milligram of plutonium is a lethal dose to the average human being.

Rare isotopes in quantities large enough for all future scientific work (medical, chemical, etc.) are now obtainable by the insertion of common materials into the pile where under the intense neutron radiation rapid transmutation takes place.

Thorium-232, found quite abundantly in the earth's crust, is not fissionable with slow neutrons, but, when placed in a uranium pile where it is bombarded by neutrons, it can be changed into U-233, which is fissionable by slow neutrons. U-235 is of course the fuel burned in the pile and the neutrons released change U-238 into Pu-239, and Th-232 into U-233.

EXERCISES

I. Underline the suffixes and prefixes and translate the following groups of words of the same stem:

pure, impure, purity, to purify, purification; danger, to endanger, dangerous, dangerously; to collide, collision, to continue, continuation, continuous, continuously; to refer to, reference; to prefer, preference; to relate, relation, relationship, relative, relatively; to lose, loss; to desire, desire, desirable, undesirable; to avoid, unavoidable; to measure, measure, measurement, measurable; to obtain, obtainable; fission, fissionable.

II. Pick up antonymical pairs out of the following list:

to insert, tightly, with, to slow down, to capture, without, absent, to withdraw, to speed up, initially, loosely, to release, eventually, present.

III. Give different meanings of the words *proper* and *too*; illustrate them in sentences.

IV. Translate the following verbs, noting the change in their meaning depending upon the prepositions and postpositions attached to them:

to carry, to carry on, to carry out; to make, to make up; to make for; to call, to call for, to call upon; to look at, to look for, to look upon; to bring, to bring up, to bring out, to bring about; to result from, to result in.

V. Write the plural of the following nouns:

phenomenon, criterion, vacuum, stratum, datum, radius, nucleus, axis, analysis, basis, focus, medium.

VI. Describe a schematic diagram of a pile of solid carbon blocks as shown in Fig. 6.

VII. Tell about the fission process.

VIII. Write a summary of the text.

46. Power Reactors or Nuclear Power Plants

The idea that the natural heat developed in a uranium or plutonium pile might be utilized as a source of great power has long been recognized as a feasible enterprise. The basic principles of one type of "power reactor" are shown in the accompanying Figure. A quantity of enriched uranium, or plutonium, in the form of a pure metal, or in the form of a soluble salt in water, forms the center of the heat-energy source.

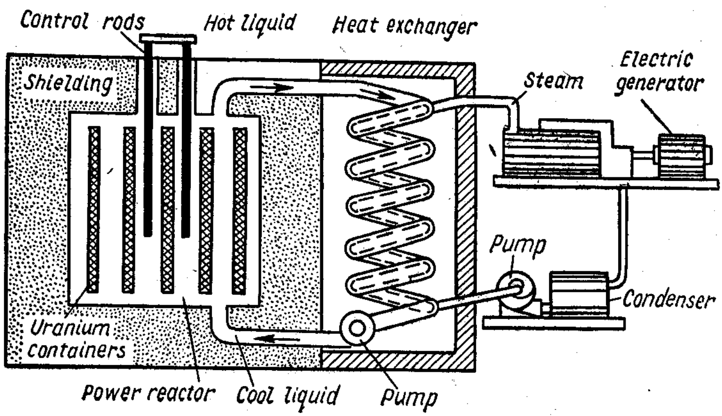

Fig. 7

The energy released by fission produces great quantities of heat and the rising temperature is regulated to a predetermined value by cadmium rods. To reduce the fission rate, and thereby lower the temperature, the central rods are pushed in a little farther to absorb more neutrons, while to raise the temperature they are pulled out a little farther.

Because of the intense neutron radiation having harmful effects to men and equipment it is not reasonable to vaporize a liquid directly as in a steam boiler; it is better to circulate a fluid through the shielded reactor and heat exchanger as shown in the diagram.

The hot liquid flowing through the heat exchanger vaporizes a more volatile liquid like water, the resulting hot gas or steam under pressure driving a turbine of special design. The turbine in turn drives an electric generator developing power that can be used to light our cities and factories, or to drive ships and submarines through the water and large planes through the air.

One of the problems connected with such power reactors concerns the effect of the intense neutron radiation on the metal structures. The neutrons change some atoms and permanently displace others from their normal positions in the crystal lattice of the solids and as a result weaken certain crucial mechanical parts. Intensive studies of the properties of various materials under conditions likely to be encountered in power reactors are continually carried on in our research laboratories.

Another important problem the scientists are facing concerns the nature of the coolant; it must be able to withstand high temperatures, not absorb neutrons and become radioactive to any appreciable extent, and yet it must be efficient in the transfer of heat in both the reactor and the heat exchanger. Certain metals with low melting points appear to be most promising in these and other respects.

EXERCISES

I. Translate the following words and word combinations:

rich, richness, to enrich; pure, purity, to purify, purification, impure, impurity; to form, form, formation; vapor, to vaporize, vaporization, to evaporate, evaporation; reason, reasonable; weak, weakness, to weaken; certain, certainly, certainty, uncertainty, to be certain; proper, properly, property; to concern, concern, concerning; as far as this question is concerned; to cool, coolant; to appreciate, appreciable; to neglect, negligible; efficient, efficiency, efficiently; value, valuable, invaluable, to evaluate, evaluation; to recognize, recognition.

II. Find in the text English equivalents for the following expressions:

этим самым, немного, в свою очередь, в результате, нецелесообразно, в значительной степени, в этом отношении.

III. Put 8 questions to the text and answer them.

IV. Describe the basic principle of one type of power reactor as shown in Fig. 7.

V. Make a report about power reactors.

VI. Write a summary of the text.

47. About Plasma

Plasma in Nature

What is a plasma?

A plasma is an approximately electrically neutral assembly of unbound (but nevertheless interacting) ions and electrons. The enormous variety of systems which fall under this general definition is such that the plasma state is appropriately described as the fourth state of matter, lying between the familiar gaseous, liquid and solid states, and the highly unfamiliar (and unnamed) fifth state in which the energy density is extremely high. The principal processes in which a plasma can be involved are interactions with electric and magnetic fields of external or selfinduced origin, and collisions of the component particles with each other or extraneous neutral matter. These collisions can in principle lead to nuclear reactions, but more frequently result only in a deflection of the particles in space.

Plasmas are all around us. Most of the universe is in the plasma state.

We may begin with the depth of intergalactic space. That "space" is now thought to be less empty than it was once supposed. It probably consists of a low density plasma, with a few X 10^{-5} particles/cm^3. According to the present cosmological theory there is a substantial amount of matter in the universe which cannot be attributed to the observed galaxies, and spectroscopic estimations make it unlikely that it occurs in atomic and molecular form.

Next on the list of distant objects are the pulsars which are of great interest to plasma physicists, due particularly to the extremely large magnetic field (10^{10} G) associated with them.

Next come the stellar galaxies which are of interest for two reasons. Firstly, they are the largest bodies of observable plasma and exhibit a rich range of plasma behaviour. Secondly, they are self-contained assemblies of gravitating "particles" and there is a close correspondence between the theory of such a system and that of a plasma.

At the same range as the galaxies are the nebulae, which are vast regions of dust, gas and plasma. These are strong sources of electromagnetic emission over the whole spectrum, with a strong polarization which has suggested that much of it is synchrotron radiation.

Moving inwards slightly, we encounter a natural thermonuclear "reactor", the sun. This has a hot central region, extending through most of the solar radius, in which fusion reactions take place, and maintain its temperature at about 10^7 K.

It has long been known that the sun exhibits a range of "localized" phenomena. These include sunspots, flares, protuberances, all bearing witness to the activity of the solar surface. All these effects are closely associated with the solar magnetic field, which rises to several kilogauss inside a sunspot.

Emerging from the surface of the sun is the solar wind. This flux of plasma with a density of 10 cm^{-3} and velocity equivalent to 1 кcV, encounters the earth dipolar magnetic field.

Coming closer to the earth, we have the ionosphere and the aurora in the upper atmosphere, and lightning and corona discharges in the lower atmosphere, and finally the ever-increasing variety of man-made plasmas.

EXERCISES

I. Read the following words with the stress a) on the first and b) on the second syllables:

a) universe, ion, galaxy, dipolar, atmosphere.

b) variety, appropriate, familiar, external, attribute, component, extraneous, exhibit, effects, associate, phenomena.

II. Find in the text English equivalents for:

Это состояние соответственно описывается как взаимодействия с электрическими и магнитными полями; друг с другом; соударения с составными частицами; согласно современной космологической теории; которые представляют интерес по двум причинам; они являются самостоятельными системами частиц; все эти воздействия тесно связаны с; и, наконец, все возрастающее множество искусственной плазмы.

III. Answer the following questions:

1. What is a plasma? 2. How is it described? 3. In what kind of processes can plasma be involved? 4. To what phenomena can the collisions of the component particles lead? 5. What does the intergalactic space consist of? 6. What does the present cosmologic theory assume? 7. What can be said about the pulsars? 8. Why are the stellar galaxies of great interest? 9. What are the nebulae? 10. What is known about the sun as a source of plasma? 11. What other sources of plasma closer to the earth are known at present?

IV. Make up a plan of the text.

V. Retell the text according to your plan.

VI. Write a summary of the text.

48. Powerhouse of the Future

Leading scientists are convinced that electric power from processes similar to those going on in the sun and the stars will become a practical proposition for energy supplies in the future. The recent Soviet step forward — the Tokamak 10 — has kindled great optimism in research centres in various countries working on Tokamaks.

At present the Soviet Union leads the world in the scale of its research, the US comes next and the countries of Western Europe jointly third.

Existing nuclear reactors are based on fission — that is "splitting" atoms of heavy elements to release energy.

The production of power from this source is of great importance, especially in view of the need to conserve resources of fossil fuels than to burn them. For these reasons some problems have been thrown up.

One is the difficulty associated with the disposal of radioactive waste. Another is the safety of reactors. A third is the depletion of supplies of uranium,— the nuclear reactor fuel.

Such problems would either not exist or be very much diminished with power generated by nuclear fusion.

This method depends on combining — that is "fusing"— the nuclei of atoms of light elements into compound nuclei, which subsequently explode with the release of energy.

The reaction which can produce useful energy will take place only at very high temperatures, around 100 million degrees centigrade — much hotter even than the temperature of the sun's surface.

The problem is how to contain the ionised gas at such temperatures, because no materials we know of can withstand such heat without vaporising.

The ingenious idea that has been developed is to use magnetic fields within a vessel to hold the gas — called plasma — away from the vessel's walls.

Research problems have involved finding the best shape and strength of the magnetic fields required to hold the plasma, so that its heat is not dissipated through the walls of the vessel before the reaction takes place.

Other problems involve finding how to get a far greater supply of useful heat and energy output from the energy input needed to heat up the plasma.

When the conditions for fusion have been met, the energy released appears as intense ultraviolet radiation which heats up the surface of the reactor wall.

In cooling this wall, steam can be produced and this in turn can drive a turbine.

Energetic neutrons produced during the process will be slowed down in a lithium containing blanket and used to produce tritium, a form of hydrogen needed in nuclear fusion, which can also be produced from naturally occurring lithium.

The main nuclear fusion fuel is deuterium, also a form of hydrogen. This occurs naturally in water.

Deuterium is available in almost unlimited supply, and known lithium deposits apart from sources yet to be discovered are also very considerable.

Lithium is found in mineral form, and also in sea water as is deuterium. Another advantage is that the process does not have the same problems of radioactive fission product waste disposal as with uranium-based nuclear power.

The abundance of the fuels required for nuclear fusion reactors will make an energy source of almost limitless magnitude.

EXERCISES

I. Find in the text synonyms for:

like, nowadays, particularly, to decrease, to occur, form, to decelerate, chief, except, appreciable.

II. Give words of the same stem and translate them:

to exist, to depend, to explode, to consider, to use, strong.

III. Find in the text English equivalents for:

кроме, удовлетворять условиям, в настоящее время, иметь большое значение, особенно, в свою очередь.

IV. Make up a plan of the text.

V. Retell the text according to your plan.

VI. Make up a summary of the text.

Part IV

RADIO ENGINEERING AND ELECTRONICS

49. Electron Emission

There is little doubt that wireless, radio, and television are among the greatest miracles of modern science. Travelling with the speed of light, code signals, the human voice and music can be heard around the world within the very second they are produced in the broadcasting studio. Through television, world events can be observed in full color at the same moment they occur hundreds of miles away.

The more we learn of the fundamental principles of radio and its operation the more amazing does their reality become.

The heart of a tube is the source of electrons. There are several ways in which free electrons are obtainable.

Thermionic Emission. The velocity of electrons and atoms, as they move about within the confines of the material they comprise, is dependent on the temperature. At a temperature of absolute zero all molecular activity is supposed to cease. As the temperature is increased, the activity of electrons and atoms increases until a point is reached where the electrons have sufficient velocity to enable them to break through the potential barrier of the material. This evaporation of electrons from the body of a solid at high temperature is known as thermionic emission. The emission or evaporation of electrons takes place at lower temperature than does that of atoms. The mass of electrons being smaller, it reaches the higher velocities necessary for evaporation at low temperatures than does the heavier atom. The temperature becoming high enough for the atoms to evaporate, the material or solid that they compose rapidly disintegrates.

Secondary Emission. *One knows to a high degree of certainty*[27] that being accelerated to a sufficiently high velocity an electron may have enough kinetic energy imparted to it to knock one or more electrons out of any material it comes in contact with, either a metal conductor or an insulator. A positively charged electrode situated near the source of these "secondary" electrons will collect them. In actual tubes the secondary electrons may be attracted back to the electrode they come from, as from the plate, or they may be collected by another electrode which is positively charged. In many tubes these secondary electrons give rise to undesirable effects, design steps being taken to reduce their number and to control their movements. In a few tubes, such as electron multipliers, the desired operation is based on the principle of secondary emission.

Photoelectric Emission. When light of proper wavelength is allowed to fall upon certain metals, electrons are released from the surface of the metal as a result of the energy imparted by the light. Here, then, is another electron source. Such sources are used in phototubes and in certain types of television camera tubes.

EXERCISES

I. Read the following words:

heart, source, enough, knock, certain, surface, wavelength, previously; confine, within, comprise, design, determine, sufficient, accelerate, disintegrate; thermionic, undesirable.

II. Find in the text synonyms for the following words:

sufficient, to wish, to gather, to speed up, rate, to limit, to stop, suitable, to believe.

III. Give derivatives from the following words and translate them:

to evaporate, to limit, to reduce, to determine, to accelerate, to attract, to desire.

IV. Find in the text the attributive clauses and give their proper translation.

V. Find in the text the sentence with the emphatic «do» and translate it properly.

VI. Choose one of the topics below and prepare to speak about it:

1. Thermionic emission; 2. Secondary emission; 3. Photoelectric emission.

VII. Compose a dialogue on electron emission.

50. Diodes

The modern diode consists of a glass envelope in which are erected a small metal plate and a fine wire called the filament. The filament in a modern tube is referred to as the cathode or emitter, its material being chosen so that it will heat when an electric current flows through it. The cathode may be a sleeve or a cylinder of metal slipped over a filament so that heat from the latter will cause the cathode to become hot. The first type is called a filament cathode; the second is known as a heater cathode, the filament merely acting as a stove or heater.

Modern manufacturing methods dictate that most tubes should be mounted on a base of some insulating material such as hard rubber, bakelite or porcelain, into which are molded metal pins through which electrical connection is made to the electrodes. Suitable sockets, into which these pins are inserted, permit easy and rapid replacement of tubes, when necessary. Figure 8 shows the essential construction of a diode tube. The cathode, when heated either directly or indirectly, emits electrons which form an indivisible cloud in the area about it. This negative cloud of electrons is called the space charge. If another electrode in the tube, such as the plate (anode), be positively charged by an external electric source (battery or generator), the electrons will be attracted to the plate, because of their being negatively charged and because the unlike fields attract. Thus there will be a continuous flow of electricity from cathode to anode across the intervening space.

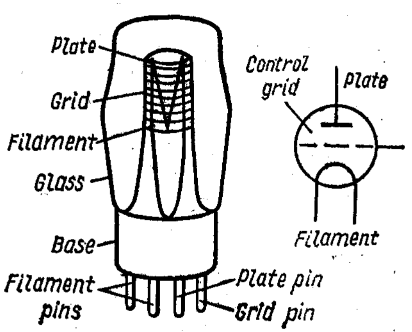

Fig. 8

The amount of current flow will depend upon the ability of the cathode to emit electrons and the amount of positive attraction at the plate, i. e., the positive charge. The positive charge being increased, the rate of the flow and the speed of the electrons will increase until a point is reached, when the cathode cannot emit electrons at a faster rate for its present temperature. This is spoken of as the saturation point. The emission rate can be increased by raising the temperature of the cathode, but the life of the tube will be shortened should the temperature exceed a fixed point. The amount of positive charge that can be applied to the plate depends upon the distance between the elements and the size of the plate. The collision of the electrons with the plate results in heat.

The plate must have enough surface area to dissipate this heat by radiation.

From the foregoing it is apparent that if an alternating current (changing polarity) is applied to the plate, a current will flow in a plate circuit whenever the plate is positive, or during every other half cycle. Further, the frequency of these d. c. pulsations will depend upon the frequency at which the alternating current reverses its polarity from positive to negative. This quality in a diode is used to convert, or rectify, alternating current to direct current.

EXERCISES

I. Find in the text synonyms for the following words and use some of them in sentences:

to be composed of, to select, to pass, only, to assemble, proper, to allow, fast, since, to attain, speed, to rise, to employ, dimension, to bring about, sufficiently, to collect, evident, to lengthen, to turn into.

II. Find in the text antonyms for the following words:

ancient, to cool, the former, soft, to withdraw, divisible, internal, to repel, like, discharge, to decrease, to lower.

III. Translate the following sentences, paying attention to the different meanings of *as*:

1. *As* the temperature increases, the activity of the electrons and atoms increases. 2. The velocity of electrons increases *as* the temperature increases. 3. *As* we know, silver is the best conductor of electricity. 4. *As* the current was flowing along the conductor, some heat was being produced. 5. All pure metals can be used *as* conductors of electricity. 6. A wire of a certain material which is twice *as long as* another wire of the same diameter will have twice the resistance. 7. When making observations, the current should be allowed to pass for half an hour and be maintained *as* constant *as* possible. 8. The flux-linkages produced in the coil that has no current in it are counted just as *though* there were a current in this coil, so that the number of times a flux line would encircle an imaginary coil current is the number of linkages contributed by this particular line. 9. For the use at radio frequency, special precaution must be observed in the design of the hotwire ammeter; in particular, inductance must be avoided *as far as possible.* 10. If two condencers are made of the same sized metal plates, but in one the plates are only half *as far* apart *as* in the other, it will be found that the one with closer plates requires twice *as much* charge *as* the other. 11. *So far as* the external circuit is concerned it makes no difference whether the current is carried by negative charges or by positive charges or by both, so *long as* all measuring and dissipating equipment responds equally well to both types of charge motion, which is generally the case.

IV. Memorize the following terms:

plate, filament, filament cathode, pin, socket, space charge, rate, to rectify.

V. Retell the text according to the plan given below:

1. The parts of a diode. 2. The insulating materials used for the base of a diode. 3. The space charge. 4. The saturation point. 5. The emission rate. 6. The current flow in a plate circuit. 7. The frequency of the direct-current pulsations.

VI. Describe the construction of a diode tube as shown in Fig. 8.

51. Three-Element Electron Tube

The insertion of the so-called third electrode between the filament and the plate has been found to make the electron tube more versatile by enabling it to serve a number of functions, especially in telephone and radio circuits. The three element tube and its circuits then appear as in Figure 9.

The effect of the grid is like that of a shutter which, opening and closing, controls the flow of electrons going through it from the filament to the plate. This control is accomplished by changing the potential of the grid. The grid being positively charged, it attracts electrons and increases their flow from the filament to the plate, for most of them pass through the relatively wide spaces between the grid wires. On the contrary the grid being negatively charged, it repels the electrons and they cannot go to the plate. Consequently, when the grid G is made alternately positive and negative by joining the input terminals to a source of alternating potential, the electron flow from F to P is increased and decreased accordingly, thereby varying the direct current in the plate circuit. The grid potential might change thousands or millions of times per second and the plate current would change accordingly. Actually, the grid is not made positive with respect to the filament, but only more or less negative. This is done by inserting a so-called C battery, as shown, to "bias" the grid negatively. When so biased there will be no current in the grid circuit. Thus, the grid serves as a gate-valve to control the plate current while taking practically no power itself.

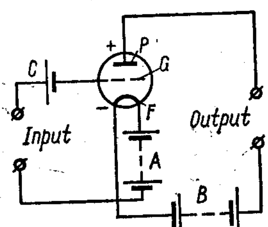

Fig. 9

The cathode of the tube is often a thin metal sleeve coated with thorium or other proper material having a low work function; a heating coil of tungsten wire is mounted within but separated from the sleeve. This construction makes it possible to heat the cathode with alternating current without introducing disturbing effects.

EXERCISES

I. Read the following words, paying attention to the pronunciation of *s*, depending upon the part of speech they belong to:

to close — close — closely; to use — use — useful — useless.

Note that in the following words the letter *s* is always pronounced as [s]:

to increase, an increase; case, basic.

II. Give Russian equivalents for the following expressions and learn them:

under proper conditions, under certain circumstances, it is customary, according to, with respect to, irrespective of, with due respect to, with regard to; regardless of, without regard to.

III. Make up sentences using some of the expressions given in exercise II.

IV. Find in the text English equivalents for:

ряд, большинство, наоборот, следовательно, более или менее.

V. Memorize the following terms:

grid, input terminal, bias, to bias, to control, work function (работа выхода), tungsten, sleeve.

VI. Put questions to the text and be ready to answer them.

***VII. Give the description of the three-element electron tube circuit as shown in Fig. 9**

VIII. Be ready to speak about diodes and triodes making use of proper schemes.

52. The Travelling-Wave Valve

In any amplifier or oscillator the function of the electron stream is to convert d. c. energy from h. f. supply to a. c. energy at the required frequency.

If a valve could be made in which a large fraction of the electrons continuously gave up their d. c. energy to the h. f. circuit over a large number of periods of the latter, a high-frequency amplifier or oscillator would result, this being to a certain extent successfully accomplished in the travelling-wave valve. The latter may be used either as an oscillator or as an amplifier. As an amplifier it is characterized by a high gain associated with an extremely large bandwidth. Its noise-factor, though not much if at all better than that of a silicon crystal is considerably less than that of a klystron. It has therefore a certain value in some special communication and radar circuits.

Imagine a concentric line the inner conductor of which is a wire helix, as in Fig. 10.

If a signal is applied across the terminals *AB*, it travels along the inner conductor to the terminals *CD* at a speed being determined by the total length of the wire forming the helix. That is, if the helix consists of *N* turns of diameter *d*, the total length $N\pi d$ and, to a first approximation, the time taken by a signal to pass from *A* to *C* is $N\pi d/c$, where *c* is the velocity of light. If the shortest distance between *A* and *C* (along the axis of the helix) is *l*, the apparent speed of the signal along *BC* is $lc/N\pi d$. By giving *N* and *d* suitable values, this axial speed may be made small compared with *c*.

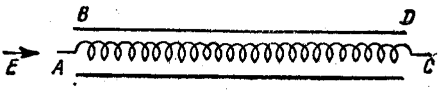

Fig. 10

Now imagine that an electron gun at *E* produces a beam of electrons travelling along *AC* with speed *v*. Then if $v = lc/N\pi d$, the electrons in the beam travel at approximately the same speed as the signal and a continuous interchange of energy between the electron stream and the circuit is feasible.

The principles of the travelling-wave valve associate the slowly moving signal with the words "travelling-wave" in contradistinction to the standing wave which exists in a klystron or a conventional valve amplifier. It should be noted, however, that the signal in a multiresonator magnetron may be regarded similarly as a travelling wave, rotating round the anode.

EXERCISES

I. Find in the text synonyms for:

rate, magnitude, to be made up of, ray, constant, link, standard like, to consider, possible, to revolve, appreciably, to transform into to demand, amplification.

II. Memorize the following words and word combinations and illustrate them in sentences:

therefore, to a certain extent, if at all, it should be noted.

III. Translate the following sentences with the "absolute phrases".

1. The energy of the electric current may be converted to work if used to drive an electric motor. 2. The other two states of matter, liquid and gaseous, possess little, if any, rigidity. 3. Not all ammeters and voltmeters will read if used in alternating-current circuits. 4. Pass an alternating current through the circuit and the lamp will glow dimly, if at all. 5. The noise factor of travelling-wave valve, though not much, if at all, better than that of a silicon crystal, is considerably less than that of a klystron. 6. When the valve of an a. c. voltage or current is quoted, it is always intended to mean the effective r. m. s. value, unless otherwise stated. 7. Although exceedingly small, gas molecules do interfere with each other when passing through small openings.

IV. Put questions to the text.

V. Describe the Figure.

VI. Be ready to speak on the travelling-wave valve.

VII. Memorize the following abbreviations:

a.c. — alternating current;
d.c. — direct current;
h.f. — high frequency;
r. m. s. — root mean square.

VIII. Memorize the following terms:

amplifier, high-frequency amplifier, valve, oscillator, travelling-wave valve — лампа бегущей волны — ЛБВ; gain bandwidth, helix, turn, beam.

53. Hot-Cathode Gas-Filled Triodes: Thyratrons

The useful properties of the hot-cathode gas-filled diode immediately suggest the introduction of a control grid. The most common valve of this type is one which contains mercury vapour but the filling gas may be helium or argon or a mixture of inert gases.

In fact, electrically, the valve acts as a switch and so has been given the name "thyratron" from the Greek word meaning a door. It opens the way to the electric current.

The thyratron grid is known to control the flow of electrons from the cathode to the anode, but only in the sense of an on/off switch. When the grid is sufficiently negative, no electrons can pass through it to the cathode, and so the current is cut off. When the grid is made less negative, there comes a stage at which a certain number of electrons can pass through it. If the anode is then sufficiently positive with respect to the cathode, these electrons produce positive ions by collision with the gas or vapour molecules. These positive ions partially destroy the space charge near the cathode, the current flowing through the valve freely. When the current has started, however, the grid can no longer control it, for making the grid more negative only increases the potential difference between it and the anode and draws to it a greater number of positive ions. These positive ions form a space charge which masks the potential of the grid wires and allows electrons to pass freely through from the cathode, since, therefore, the grid looses control of the current which it has initiated, to render the thyratron nonconducting, again it is necessary to cut off the positive potential applied to the anode. When the current ceases, the grid regains control.

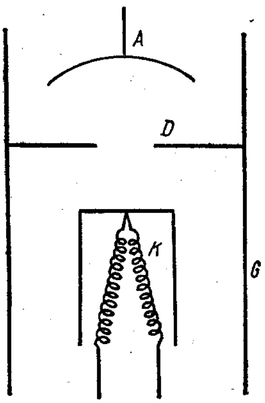

Fig. 11

The thyratron is not constructed in the same manner as the conventional high-vacuum valve. The usual structure is shown diagrammatically by the axial section drawn in Fig. 11, where the cathode is an indirectly-heated cylinder, K, coated with oxides. The grid, G, is a cylinder surrounding the cathode and containing an annual disk, D. Opposite the aperture in the disk, the cup-shaped anode is placed. This old construction is used for two reasons. First, as in the gas diode, it is unnecessary for the emitting surface of the cathode and the collecting surface of the anode to be placed opposite each other, and secondly, since an extremely-small primary electron current is sufficient to start the valve conducting, the grid control must be made as strong as possible. In fact, no electrons should be able to reach the anode when the grid is at a reasonably high negative voltage. The grid cylinder, G, therefore almost completely surrounds the cathode, leaving only a narrow aperture near the anode. The critical grid voltage, V_{go}, at which the valve begins to conduct (or "strikes" as it is called) varies with the anode voltage V_a.

However, with the valve containing mercury vapour, the critical grid voltage also varies with the temperature, for the mercury-vapour pressure determines the onset of ionization to a certain extent. For example, if $V_{gc} = -6.5$ at $V_a = 1{,}000$ and at an effective temperature of 40° C, V_{gc} might be — 10 at a temperature of 70° C and —3 at 35° C. This variation of a striking voltage with temperature can be a grave disadvantage where large changes in temperature are experienced.

EXERCISES

I. Read the following words:

control, contain, compare, suggest, suppress, support, collision, division, cathode, molecule, mercury.

II. Read, translate and memorize the following technical terms:

hot-cathode gas-filled diode, mercury vapour, space charge, argon positive ions, rare gases, mercury-vapour pressure, cup-shaped anode, travelling wave, standing wave, a multi-resonator magnetron, indirectly-heated cylinder.

III. Find in the text synonyms for:

at once, usual, tube, to ruin, to permit, to stop, to indicate, to cover, weak, to attain, entirely, to differ, to define, in fact.

IV. Find in the text antonyms for:

useless, to shut, positive, restore, different, the end, advantage, increase.

V. Give Russian equivalents for:

with respect to, no longer, in the same manner, to a certain extent, as compared with, up to, for that reason.

VI. Make up nouns from the following verbs:

to collide, to differ, to apply, to determine, to vary, to conduct, to lose, compare, to drop.

VII. Illustrate in sentences of your own the different meanings of: do, for, since.

VIII. Translate the following sentences paying attention to the ways negations are expressed:

1. *No change occurs* in the pressure of a confined gas even if it is allowed to stand for long periods of time. 2. *No materials are* perfectly elastic. 3. The physicist *no longer* believes that an electron always occupies the same orbit when the atom is in its normal state. 4. The vaccum-tube voltmeter has made possible the measurement of voltages in circuits where any other form of instrument would so disturb the conditions that they would *no longer* be normal. 5. It was *not until* the beginning of the XVII century that the discovery that many substances can be electrified by friction was announced. 6. It was *not until* the latter part of the 19th century that the gas acetylen was produced in sufficient quantities to make welding possible on a large scale.

IX. Describe the structure of the thyratron as shown in Fig. 11.

X. Retell the text according to the plan of your own.

54. Rectifiers

Rectifiers are devices designed to convert alternating current into direct current. For this purpose devices with assymetrical conductance such as vacuum and semiconductor diodes are used. Until the end of the twenties of this century vacuum diodes (kenotrones) were the main rectifying devices. In the thirties high-power kenotrones were replaced by more efficient mercury vapour rectifiers. At present high-power gas-filled and gas-control tubes are used. Low-power recti-

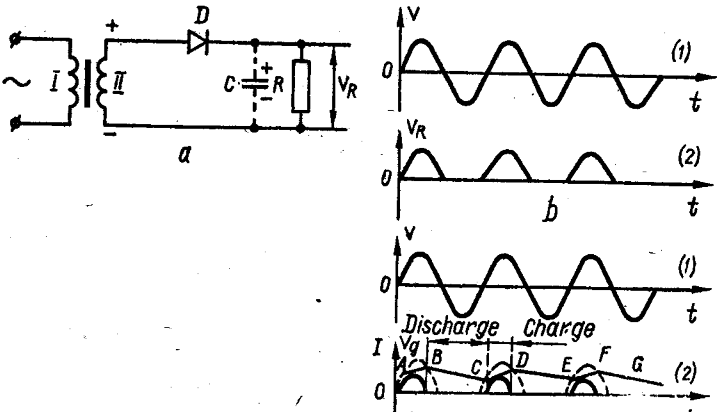

Fig. 12

fiers mostly used in low and medium power rectifying systems are replaced by highly efficient and reliable semiconductor rectifiers.

Let us examine the simplest types of rectifiers.

a) Half wave rectifiers (Fig. 12).

The load resistor R is connected in series with the transformer secondary and the semiconductor rectifying diode D. The wave-form in graph 1 shows the change in voltage across the transformer secondary. Due to inherent rectifying properties the diode conducts current only during the positive half-waves of the voltage cycles.

The current I and the output voltage V_R are of a pulsating pattern (graph 2). To smooth these pulsations a capacitor C is connected across the load.

When the transformer output voltage goes negative or drops lower than the voltage applied to the capacitor, the diode does not conduct current and the capacitor is discharged through load resistor R (sections BC, DE, FG).

b) Full-wave rectifiers can be considered as composed of two half-wave rectifiers connected to one common load. Shown in the figure 12 is a full-wave rectifier with two rectifying elements and a centre-tapped secondary winding on the transformer. When the voltage on the upper terminal of the secondary is positive with respect to the centre tap, diode D_1 conducts current I_1 in the direction indicated by an arrow. During the next half-wave the voltage polarity will be reversed and Diode D_2 will conduct current I_2 to the common load. During both half-waves the current through the load resistor R (I_1 and I_2) is of the same direction, the output current $I = I_1 + I_2$ being of a pulsating wave-form.

EXERCISES

I. Form derivatives from:

to convert, to conduct, to rectify, efficient, to relate, to resist.

II. Make up sentences using the following words and word combinations:

under these conditions, for this purpose, at any time.

III. Translate the following terms and memorize them:

vacuum diodes; output voltage; a load resistor; transformer secondary; a center-tapped secondary winding; transformer output voltage; full-wave rectifiers; pulsating wave-form; mercury vapour rectifiers.

IV. Put questions to the text.

V. Be ready to speak about:

1. The development of rectifiers. 2. Their application. 3. Half-wave rectifiers. 4. Full-wave rectifiers.

VI. Describe the half-wave rectifier according to Fig. 12.

VII. Describe a full-wave rectifier.

VIII. Translate into English:

Выпрямители — это устройства, преобразующие переменный ток в постоянный. Вакуумные диоды (кенотроны) мощностью от нескольких ватт до нескольких десятков киловатт были основными выпрямительными элементами в 20 годах. Позже появились ртутные выпрямители. В настоящее время их заменили мощные газотроны и тиратроны. Полупроводниковые вентили более экономичны и надежны в работе.

5*

55. At the Laboratory

A rectifier is being demonstrated to a group of students. The demonstrator is asking the students.

Demonstrator: What are vacuum-tube rectifiers used for?

Student: Vacuum-tube rectifiers are used for converting the high-voltage alternating current delivered from the secondary of a power transformer into direct current.

Demonstrator: That's right. You should mention that the direct current is required by radio receivers and transmitters. What principle of electron flow are these rectifiers based upon?

Student: As a matter of fact, these rectifiers employ the principle of electrons flowing from the cathode to the anode only when the anode has a positive charge applied to it.

Demonstrator: What elements does a duo-diode vacuum tube consist of?

Student: It consists of two anodes or plates and a single filament or cathode.

Demonstrator: O'key. What voltage is induced in the secondary and how do the electrons move?

Student: If I'm not mistaken, the voltage induced in the secondary is an alternating one, the electrons move in one direction as the primary field expands, and in the opposite direction as the field collapses.

Demonstrator: That's all right. What does this cause?

Student: Sorry, I don't know.

Demonstrator: This causes the plates in the vacuum tube to be alternately positively and negatively charged at a rate dependent upon the frequency of the primary variations. And do you know how the electrons being emitted by the double-peaked cathode flow?

Student: It seems to me that the electrons always flow out of the centre tap, the result being unidirectional or direct current.

Demonstrator: How is the filament of the rectifier tube heated?

Student: A smaller secondary winding is provided to heat the filament.

Demonstrator: Do you know anything about additional secondary coils?

S t u d e n t: As far as I know, these may be provided to supply voltage for heating filaments in vacuum tubes used in receivers or transmitters.

D e m o n s t r a t o r: Is this type of rectifier of full-wave or half-wave type?

S t u d e n t: This type of rectifier is the full-wave type, because of its passing both alternations of each cycle applied to it.

D e m o n s t r a t o r: That will do!

EXERCISES

I. Read fluently:

the secondary of the power transformer, the frequency of the primary variations, the center tap of the transformer secondary, the return lead from the load circuit, additional secondary coils, such as required, such as is mentioned above.

II. Find in the text synonyms for the following verbs. Use some of them in sentences:

to turn into, to use, to demand, to impress, to supply, to speed up.

III. Find in the text antonyms for the following words:

to contract, to cool, to answer, indirect.

IV. Write words of the same stem and translate them:

to alter, to receive, to direct, to rectify, to apply, to induce, to move, to add, to emit.

V. Learn the dialogue.

VI. Memorize the following terms:

vacuum-tube rectifier — ламповый выпрямитель; high-voltage alternating current — переменный ток высокого напряжения; secondary winding — вторичная обмотка; a filament — нить накала, катод; primary field — первичная обмотка; centre tap — с ответвлением в центре; full-wave — двухполупериодный; half-wave — полупериодный.

56. Vacuum-Tube Oscillator

To broadcast the human voice by radio, a generator of alternating current of extremely high frequency and constant amplitude is required. In commercial broadcasting stations and amateur transmitters this function is performed by a vacuum tube and circuit of relatively simple design.

One type of oscillator circuit is shown in Fig. 13. When the switch S is closed connecting the B-battery to the plate of the tube an electron current from the cathode K to the plate P starts a current in the circuit $PRVL_3K$. This growing current in L_3 creates an expanding magnetic field, which cutting across L_2 induces a current in the grid circuit in such a direction that the grid becomes negative. A negative charge on the grid causes the plate current to decrease. This decreasing current causes the field about L_3 to collapse, thus inducing a reversed current in the grid circuit and therefore a po-

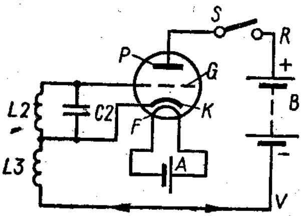

Fig. 13

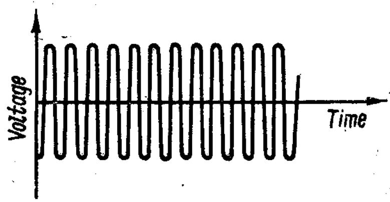

Fig. 14

sitive charge on the grid. Such a charge increases the plate current and the above process is repeated.

If the two circuits L_2C_2 and $PRVL_3$ were properly tuned by adjusting C_2 resonance would occur and energy from the B-battery would be continuously supplied to keep the oscillations going with constant amplitude. The graph of the continuous oscillations shown in Fig. 14 represents the voltage

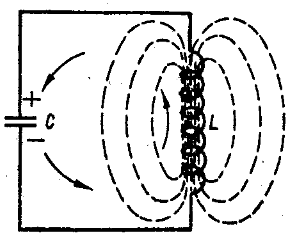

Fig. 15

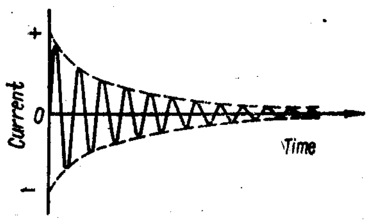

Fig. 16

across L_3 as it varies in time. The L_2C_2 circuit controls the frequency by controlling the grid potential while the large voltage and current fluctuations take place in the L_3 circuit.

The oscillatory circuit. An inductance and capacitance, connected as shown in simplest, schematic form in Fig. 15 form the necessary elements of all oscillating circuits.

If initially the capacitance is charged as indicated, the surplus electrons on the plate below cause a surge of negative charge counterclockwise around the circuit to neutralize the positives and, in so doing, set up a magnetic field in and around the inductance. When the positives become neutralized and the electron current tends to cease, the magnetic flux linking the circuit decreases and keeps the current flowing in the same direction. Once this field has vanished and the current has ceased, the capacitance is found to be in a charged condition, the upper plate being negative and the lower plate positive.

Having reversed the charge on the capacitance, the above process will repeat itself, this time the electron current surging clockwise around the circuit. Thus the current rushes first in one direction, then in the other, oscillating back and forth in an electrical way just as any spring pulled to one side and released vibrates in a mechanical way.

When a straight spring is pulled to one side and released, the kinetic energy it gains upon straightening keeps it moving and it bends to the other side. Just as the vibration amplitude of the spring slowly decreases because of friction, so also does the current in the electrical circuit decrease due to electrical resistance. A graph showing how current slowly dies out in an electric circuit is given in Fig. 16.

These are called damped vibrations, or damped oscillations. If the resistance of the circuit is high, the damping is high and the current quickly dies out after but few oscillations. The resistance being low, however, the damping is small, the amplitude decreases slowly, and there are many oscillations.

EXERCISES

I. Find in the text synonyms for:

permanent, to demand, to fulfil, to join, to force, to take place, originally, to stop, to be referred to as, to reduce.

II. Give antonyms for the following words:

the former, to finish, to decrease, clockwise, to appear, low, slowly.

III. Find in the text the sentences with:

a) Perfect Participle Active;
b) Complex Object with the Infinitive;
c) Complex Subject with the Infinitive;
d) Absolute Participial Construction.

IV. Put 5 questions to the text.

V. Retell the text.

VI. Make up a summary of the text.

VII. Describe the type of oscillator circuit and the graph of the continuous oscillations as shown in Fig. 13 and 14.

VIII. Translate and memorize the following terms:

потенциал сетки, обратный ток, анодный ток, колебательный контур, емкость, индуктивность, затухающее колебание.

57. Radio-Frequency Amplifiers

The functions of a radio-frequency amplifier are to increase the voltage of the radio-frequency (r. f.) signal and to secure the required selectivity of the receiver.

The voltage applied to the input of a r. f. amplifier is from units to hundreds of microvolts depending on the sensitivity of the receiver. Before the signal reaches the detector it should be amplified a million times or more. Such voltage gain may be obtained only with the aid of several amplifier stages.

A r. f. amplifier stage contains a valve or a transistor and a load, which is a resonant circuit tuned to the frequency of the signal applied to the input of the stage. This resonant circuit may be a single tuned circuit or a band-pass filter.

R. f. amplifiers in which single-tuned circuits serve as a load are known as tuned amplifiers. In case r. f. amplifiers employ band-pass filters for load they are called band-pass or filter amplifiers.

Band-pass amplifiers have a nearly rectangular resonance curve. They are mostly fixed frequency amplifiers, i. e. their tuned circuits do not have to be retuned when the receiver is in operation. Band-pass amplifiers are widely used as i. f. amplifiers in superheterodyne receivers.

In a band-pass amplifier the anode load is a band-pass filter which may have widely differing circuit configurations and may be connected to the anode of the amplifier valve in many ways.

EXERCISES

I. Form derivatives from:

to amplify, to arrange, to depend, to design, to increase, sensitive, to select, to detect.

II. Memorize the following terms:

voltage gain — усиление напряжения; i. f. amplifier — усилитель промежуточной частоты; r. f. amplifier — усилитель высокой частоты; band-pass amplifier — полосовой усилитель; tuned amplifiers — резонансные усилители; single-stage band-pass amplifier — усилительный каскад с полосовым фильтром.

III. Answer the following questions:

1. What are the functions of r. f. amplifiers? 2. What voltage is applied to the input of a r. f. amplifier? 3. How is a voltage gain obtained? 4. What classes of r. f. amplifiers do you know? 5. What is the difference between band-pass or filter amplifiers and tuned amplifiers? 6. What are tuned amplifiers used for?

IV. Translate into English:

Усилители высокой частоты предназначены для усиления напряжения колебаний высокой частоты и обеспечения необходимых избирательных свойств приемника. Усиление обеспечивается использованием нескольких каскадов, которые выполняются как на электронных лампах, так и на транзисторах. Усилители, в которых нагрузкой служит одиночный колебательный контур, называются резонансными. Те усилители, в которых используются полосовые фильтры, называются полосовыми.

V. Make up a plan of the text.

VI. Retell the text according to your plan.

58. General Classification of Amplifiers

It is common knowledge that amplifiers are divided into three general classes: A, B and C, depending on the type of service in which they are to be used.

A class A amplifier is one which operates so that the plate output wave shapes of current are practically the same as those of the exciting grid voltage. This is accomplished by operating the tube with sufficient negative grid bias so that some plate current flows at all times and by applying an alternating excitation voltage to the grid of such value that the dynamic operating characteristic is essentially linear. The grid must not go positive on excitation peaks, and the plate current must not fall low enough at its minimum to cause distortion due to curvature of the characteristics. We know the characteristics of class A operation to be free from distortion and relatively low power output, practically all a-f amplifiers being operated in this manner.

Radio-frequency amplifiers of the type used in receiving sets to amplify the signal voltage prior to detection are also considered to be of this class.

Class B amplifiers are operated with a negative bias approximately equal to cutoff so that the plate current is almost zero when the alternating grid excitation is removed. With a sinusoidal voltage applied to the grid, the plate current consists of a series of half-sine waves, similar to the output of a half-wave rectifier. The load impedance is adjusted so as to obtain an approximately linear dynamic characteristic. The grid swings positive on excitation peaks, causing grid current to flow. We know of class B amplifiers being used in radio-telephone transmitters following the modulated stage.

The power output obtainable from a given tube is much greater than with class A operation, the plate efficiency being much higher. As with a-f power amplifiers, tubes operating as class B r-f amplifiers may also be operated in push-pull.

A class C amplifier is one in which high output and plate efficiency are the primary considerations. The grid is negatively biased to a point considerably beyond cutoff, so that the plate current is zero with no grid excitation. The latter is quite large and is often sufficient to cause the plate current to reach saturation on positive swings. Plate efficiencies in the vicinity of 90 per cent may be obtained with the larger tubes, these high efficiencies being made possible by allowing the plate current to flow during less than 180 deg. of the cycle and only at a time when the plate potential is comparatively low. In radiotelegraph transmitters all stages are operated in class C, while with radio-telephony it is only the modulated amplifier and the stages preceding it that are so operated.

Either triodes or screen-grid tetrodes may be used as power amplifiers. The latter have the advantage of not requiring neutralization. The screen-grid voltage in transmitting tubes is usually about 15 per cent of the plate supply voltage, which is proportionally much lower than in receiving tubes. These tubes are difficult to construct for power outputs much greater than 500 watts, and, where larger outputs are required, triodes must be used.

EXERCISES

I. Find in the text synonyms for the words given below:

form, magnitude, neighbourhood, commonly, enough, to perform, nearly, like, to give rise to, owing to, in this way, to employ, to regulate, to receive, to make, appreciably, to attain, to permit, to demand, to be composed of, a number of, merit, before.

II. Find the suffixes and prefixes in the following words and translate these words:

obtainable, adjustable, sufficient, usual, essential, relative, powerful, distortionless, untuned, constant, further, characteristic, possible, distant, amplification, amplifier, output, input, disadvantage, linearity, freedom, darkness, resistance, efficiency, inventiveness, internal, external, to amplify, to neutralize, to strengthen, to lower, to rectify.

III. Find in the text antonyms for the words given below:

different, to rise, positive, to insert, unlike, disadvantage, the former, slightly, to follow, easy, input.

IV. Translate the following phrases and make up sentences usins them:

it is common knowledge, it is common observation, it is common practice.

V. Make up a plan of the text.

VI. Retell the text according to the plan.

VII. Write a summary of the text.

VIII. Give Russian equivalents for the following terms:

power output, load impedance, negative grid bias, exciting grid voltage, plate output wave shape, half-sine wave.

IX. Give English equivalents for the following terms:

усилитель мощности, анодный ток, отрицательное смещение, отсечка, полупериодный выпрямитель, тетрод с экранированной сеткой, напряжение питания анода.

59. Transistor Radio Frequency Amplifiers

Like valve amplifiers a transistor r. f. amplifier may be of the tuned or of the band-pass variety.

On long, medium and short waves, the transistor is usually connected into a common emitter circuit while in the VHF and UHF bands use is sometimes made of the common base arrangement.

Transistor amplifiers differ from valve amplifiers in interstage coupling. Operation of a transistor amplifier is affected by the output resistance of the transistor, which is much lower than the output resistance of an amplifier valve. This is why transformer and tapped-coil coupling is used extensively in r. f. transistor amplifiers.

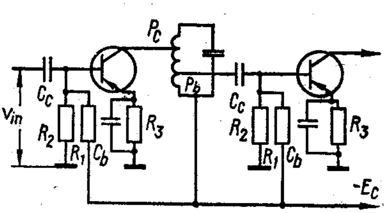

Fig. 17

The stability of the operation of a transistor amplifier largely depends on the position of the quiescent operating point. To stabilize this point the circuit employs negative direct-current feedback provided by R_3 (Fig. 17) connected in the emitter circuit. Such an arrangement is similar to the current feedback arrangement in valve circuits.

To eliminate a. c. feedback R_3 is bypassed to earth by C_6. Should the operating point shift due to temperature changes it will be restored by the feedback voltage built up across R_3 and applied to the transistor base. It should be noted however that in both configurations the tuned circuit may be connected to the collector circuit directly, provided the output resistance of the transistor is sufficiently high.

EXERCISES

I. Give the words of the same stem and translate them into Russian:

variety, connection, selectivity, restore, arrange, resistance, directly.

II. Find in the text English equivalents for the following expressions:

значительно ниже, вот почему, в значительной степени, зависеть от, отличаться от.

III. Give different meanings of the words:

like, proper, provided.

Illustrate them in sentences.

IV. Translate the following terms and memorize them:

valve amplifiers, interstage coupling, the feedback voltage, the amplifier valve, the output resistance, the input resistance, transistor r. f. amplifier, common-emitter circuit, common-base arrangement, the current feedback arrangement, the common emitter r. f. tuned amplifier.

V. Put questions to the text.

VI. Be ready to speak about the difference between transistor and valve amplifiers.

VII. Describe the operation of a transistor amplifier as shown in Fig. 17.

VIII. Translate into English:

Усилители высокой частоты на транзисторах могут быть резонансными и полосными. В диапазонах длинных, средних и коротких волн транзистор включается по схеме с общим эмиттером. В диапазонах СВЧ иногда применяется включение по схеме с общей базой. Усилители на транзисторах отличаются от ламповых по способу связи между каскадами. Стабильность работы транзисторного усилителя в большой мере зависит от постоянства исходной рабочей точки, положение которой меняется при нагреве триодов.

60. Radio Transmitters

I

General Considerations. A radio transmitter is known to be essentially a device for producing radio-frequency energy that is controlled by the intelligence to be transmitted. A transmitter accordingly represents a combination of oscillator, power amplifiers, harmonic generators, modulator, power-supply systems, etc., which will best achieve the desired result.

Commercial transmitting equipment is ordinarily mounted on a framework of structural-steel members fronted by a vertical metal panel containing the controls and meters necessary for adjusting and monitoring the transmitter. All equipment appearing on the panel is at ground potential, instruments which must be observed during adjustment or operation and which are not at ground potential being located behind the panel and viewed through windows. The steel frame is normally enclosed with wire mesh of some sort and is provided with doors that cut off the transmitter power when opened. This type of construction requires a minimum of floor space in proportion to the amount of apparatus involved, makes the transmitter accessible for inspection and repairing, and eliminates all hazard to persons.

The design of most radio transmitters, particularly those intended for broadcast and short-wave transmission, is dominated by the need of maintaining the transmitted frequency as nearly constant as possible over long periods of time. In broadcast work two or more transmitters are commonly assigned the same carrier frequency, and in order to minimize the resulting interference it is essential that the carrier frequencies be as nearly as possible the same.

The Microphone Transmitter. The microphone transmitter may be one of the ordinary carbon granule type. Without going into details, it will suffice to state here that such a microphone consists simply of an elastic diaphragm bearing against a mass of carbon granules enclosed in a suitable chamber, the carbon granules forming part of an electrical circuit. When the microphone is not being spoken into the diaphragm remains stationary and exerts a constant pressure upon the carbon granules, the resistance of which remains, therefore, constant. On the other hand, when the diaphragm is set vibrating, as it is done by speaking into the microphone or through a noise or sound reaching it, the pressure exerted by the diaphragm against the carbon granules changes, and this change of pressure causes the resistance of the carbon granules to increase or decrease in accordance with the displacement of the diaphragm from its position of rest.

When the microphone is not being spoken into, the alternator produces a high-frequency current of constant amplitude, i. e., an undamped current; the amplitude of this current is adjusted to the maximum by adjusting the inductance so as to make the natural frequency of the circuit equal to the frequency of the alternator.

Now, assume, for the sake of simplicity, a vibrating tuning fork to be placed in front of the microphone. The harmonic vibrations of the tuning fork will bring about harmonic vibrations of the microphone diaphragm, and these will produce variations in the resistance of the microphone. Since no other part of the circuit is undergoing any change, it is plain that a variation of the microphone resistance will produce a corresponding variation in the amplitude of the high-frequency antenna current. Thus, when the diaphragm is displaced inwardly the resistance of the microphone and, therefore, of the entire alternator circuit, decreases, and the amplitude of the current supplied by the alternator must necessarily increase, the reverse taking place when the diaphragm is displaced outwardly.

EXERCISES

I. Read fluently:

an elastic diaphragm, an emitting surface, an undamped current, one of the ordinary types, a mass of carbon granules, the displacement of the diaphragm, in accordance with the displacement, irrespective of the frequency, for the sake of simplicity.

II. Make up sentences, using the following words and word combinations:

on the other hand, in other words, for the sake of, therefore, whether... or, it will suffice to, to bring about.

III. Be ready to answer the following questions:

1. What is a radio transmitter used for? 2. What parts does a transmitter consist of? 3. Where is the transmitting equipment ordinarily mounted? 4. At what potential does all the equipment operate? 5. What are the advantages of this type of construction? 6. Why are two or more transmitters commonly assigned the same carrier frequency in broadcast work?

IV. Describe the work of a microphone transmitter.

V. Write a summary of the text " Radio Transmitters".

61. Radio Transmitters

II

To use an oscillating tube circuit, as part of a radio transmitter the high frequency oscillations in the L_2C_2 circuit must be modified by sound waves and then applied

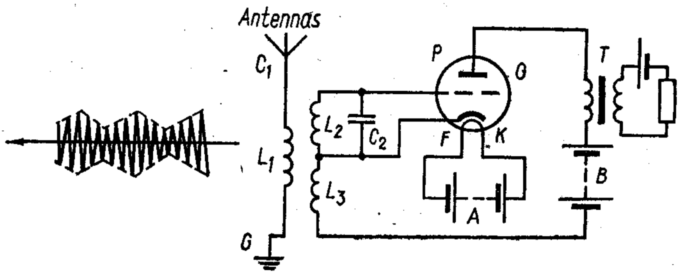

Fig. 18

to an antenna and ground system for broadcasting as electromagnetic waves. A simplified circuit diagram showing one of the many ways of doing this is given in the figure below. There are three parts to this particular "hook up", (1) the microphone circuit containing a battery D and a transformer T, (2) the oscillator circuit in the middle, and (3) the antenna circuit C_1L_1G at the left.

By talking or singing into the microphone the diaphragm inside moves back and forth with the sound vibrations, thus altering the steady current previously flowing around the circuit DMX. Current pulsations in X, the transformer primary, cause similar pulsations in Z, the secondary circuit carrying the plate current. The effect of the relatively low frequency audio currents on the high frequency oscillations already there is to alter their amplitude.

The modulated oscillations are induced in the antenna circuit by resonance, and are radiated as electromagnetic waves of the same frequency and form. The continuous wave produced by the radio frequency oscillations alone is called the carrier wave, the alteration of its amplitude by audiofrequencies being spoken of as modulation. Athough radio transmitters with one vacuum tube have been used by radio amateurs, it is customary to find transmitters with half a dozen or more tubes. The principal function of additional tubes in receivers as well as transmitters is to amplify currents wherever they are needed and thereby give greater transmitting range and clearer reception.

EXERCISES

I. Read fluently:

as part of a radio transmitter, a ground system for broadcasting, one of many ways of doing this, a battery and a transformer, the diaphragm inside moves back and forth, the effect of the relatively low frequency audio currents, are radiated as electromagnetic waves, produced by the radio frequency oscillations, the function of additional tubes in receivers.

II. Find in the text:

1) the Infinitives and the Infinitive Constructions;
2) the sentences with Idiomatic Passive.

Analyse and translate them properly.

III. Answer the following questions:

1. What must be done in order to use an oscillating tube circuit as a part of a radio transmitter? 2. What does talking or singing into the microphone cause? 3. What do current pulsations in the transformer primary cause? 4. How are modulated oscillations induced in the antenna circuit? 5. What is called a carrier wave? 6. What is modulation? 7. What kind of radio transmitters have been used by radio amateurs? 8. What is the principal function of additional tubes in receivers and transmitters?

IV. Describe the simplified circuit diagram represented in Fig. 18.

V. Give English equivalents for:

принято, как..., так и, удовлетворять требованиям, принимать во внимание, по крайней мере, за счет, сверх, по сравнению с...

VI. Write a summary of the text " Radio Transmitters".

VII. Make a short report about the operation of radio transmitters in general.

VIII. Translate the following terms and memorize them:

power-supply system, oscillator, to monitor, broadcast, carrier-frequency, interference, transformer primary range.

IX. Translate into English the following terms:

регулировка, выходная мощность, коротковолновая передача, несущая частота, помехи, собственная частота, вещание.

X. Translate into English:

Радиопередатчик служит для генерации и излучения высокочастотных колебаний.

Передатчик представляет собой сочетание генераторов, усилителей, модулятора, систем питания и т. д. Он должен удовлетворять следующим требованиям: 1) несущая частота колебаний, излучаемых антенной, должна быть постоянной; 2) выходная мощность передатчика должна быть определенного уровня; 3) цепи передатчика не должны вызывать искажений сигнала; 4) к. п. д. передатчика должен быть высоким.

62. Radio Receivers

I

Transmission of intelligence by radio is based on modulation, this being a process by which the message to be transmitted is superimposed at the sending end of a radio link as a modulating signal on a strong carrier wave, thereby changing the latter's amplitude, frequency or phase. The modulated carrier is radiated by a transmitting aerial as a wave of electromagnetic energy which propagates through space at the velocity of light. At the point of reception the modulated wave is picked up by a receiving aerial and is fed to the receiver input. In the receiver the signal is separated from the radio-frequency carrier and drives the receiver load, which may be a speaker, a recorder, a cathode-ray tube, etc. As an electromagnetic wave travels away from the transmitter it is weakened or attenuated. This is why radio receivers should be capable of picking up relatively weak signals.

Radio serves a variety of purposes such as communication, broadcasting, navigation, radar and telecontrol.

Radio communication is the transmission and reception of messages without wires or waveguides. It includes communication by radio telegraph, radio-telephone, radio teletypewriter, radio facsimile and television. It is the only method of communication between stationary and mobile objects (e. g. from ship to shore, from ground to aircraft, from ground to spaceships, etc.).

Radio broadcasting is radio transmission for general reception, including speech, music and commercial television.

Radio navigation is the use of radio facilities for determining the position and direction of ships and planes.

Radar (which is an acronym for Radio Detection and Ranging) is a technique for determining the range and bearings of objects (targets) by transmitting beamed high-power signals against reflective targets, the reception of the reflected signals and the presentation of the resultant data on a dial or a cathode ray display.

Telecontrol is a technique for control of machinery by radio.

There exist two classes of receivers: communication and broad-cast receivers, the former being used in point-to-point radio telephone and telegraph service while the latter are designed for the reception of sound and visual programmes.

EXERCISES

I. Give the words of the same stem:

transmission, reception, to propagate, modulation, separation, generation, presentation, variety, radiation, recorder, frequency.

II. Arrange the following words into synonymical pairs:

technique, to weaken, to receive, purpose, velocity, application; to obtain, to attenuate, use, aim, method, speed.

III. Give Russian equivalents for the following terms:

receiver input, electromagnetic wave, radio broadcasting, waveguide, modulated wave, high-power signals, radio-frequency carrier, cathode-ray tube, beamed high-power signals, cathode-ray display, radio-navigation system, frequency-modulated receivers, amplitude-modulated receivers, tuned radio-frequency receivers.

IV. Translate into English:

передача информации по радио; передающая антенна; распространяться со скоростью света; радиосвязь; прием и передача сообщений; телеуправление; электромагнитные волны затухают; по типу модуляции, полученные данные, принцип действия, единственный метод, относительно слабые сигналы.

V. Answer the following questions:

1. What is transmission of intelligence based upon? 2. What is modulation? 3. In what way is the modulated carrier radiated? 4. What property must any radio receiver possess? 5. What purposes does radio serve? 6. What application has radio communication? 7. What is the use of radio navigation? 8. What principle is radar based upon? 9. In what fields is telecontrol used? 10. What classes of radio receivers do you know?

VI. Translate into English:

Модуляцией называется процесс воздействия полезного сигнала на амплитуду, частоту или фазу колебаний высокой частоты, получаемых в радиопередатчике. Модулированные колебания высокой частоты излучаются передающей антенной в виде электромагнитных волн, распространяющихся в пространстве со скоростью света. В радиоприемнике из принятого модулированного сигнала высокой частоты выделяется полезный сигнал, который подается на оконечный аппарат и приводит его в действие.

По мере удаления радиоприемника от радиопередатчика энергия электромагнитных волн уменьшается. Вот почему радиоприемник должен обеспечивать прием сравнительно слабых сигналов.

VII. Be ready to report on:

1. Radio communication. 2. Radio broadcasting. 3. Radio navigation. 4. Radar. 5. Telecontrol. 6. Communication receivers and their uses. 7. Broadcast receivers. 8. a-m and f-m receivers.

63. Radio Receivers

II

The simplest possible receiver is exactly the same as used for spark telegraphy. The manipulations necessary for the operation of this receiver are the same as for any spark receiver; the antenna circuit and the closed circuit must be tuned to the incoming high frequency, and the coupling between the antenna circuit and the closed circuit should ordinarily be made loose. The e. m. f. impressed upon the receiving antenna, due to the electromagnetic waves emanating from the transmitter is known to produce a current in receiving antennas which will be a reproduction of the current in the transmitting antenna. Assume, for the sake of simplicity, the rectifier used in the receiving circuit to have a characteristic such that a negative e. m. f. impressed upon the circuit of the rectifier produces no current whatsoever, a positive e. m. f. producing a current varying directly with the e. m. f. As a matter of fact, the e. m. f. impressed upon the receiving antenna and transferred to the rectifier circuit by suitable coupling coils will produce a current in the rectifier circuit. The current, though unidirectional, is yet one changing at high frequency, and as such it cannot flow through the high impedance winding of the telephone receiver, the current in the receiver being the average current. It will be noted that the current in the telephone receiver which corresponds to a period of activity of the microphone at the distant transmitting station, is one which changes periodically, between a maximum and a minimum, at the "modulating frequency", on the other hand, the current corresponding to a period during which the microphone transmitter is idle, is constant.

Characteristics of Broadcast Receivers. The most important characteristics of a receiver for radio-telephone signals are the sensitivity, the selectivity, and the fidelity. The sensitivity represents the ability of the receiver to respond to small radio-signal voltages, and is measured quantitatively in terms of the voltage that must be induced in the antenna by the radio signal to develop a standard output from the power amplifier. This standard output has been arbitrarily chosen as 0.05 watt in a non-inductive load resistance having a value corresponding to the load resistance into which the power amplifier is designed to operate. The sensitivity is arbitrarily defined as the effective value of the carrier voltage that must be induced in the antenna to develop this standard output when the carrier is modulated 30 per cent at a frequency of 400 cycles. The sensitivity is measured with the radio receiver tuned to give maximum response at the carrier frequency involved and with the volume controls adjusted for maximum volume.

Selectivity is the property that enables a radio receiver to discriminate between radio signals of different carrier frequencies. Selectivity cannot be defined in a single term as can sensitivity but must be expressed in the form of curves, which shows the amount by which the signal input must be increased in order to maintain the standard output as the carrier frequency is varied from the frequency to which the receiver is tuned. These curves therefore indicate the extent to which interfering signals are discriminated against, and in general will depend somewhat on the carrier frequency.

Fidelity represents the extent to which the receiver reproduces the different modulation frequencies without frequency distortion. The fidelity of a radio receiver is expressed in curves, which give the variation in audio-frequency output voltage as the modulation frequency of the signal is varied. In order to facilitate comparison, the output is expressed in terms of the ratio of actual output to the output obtained when the modulation frequency is 400 cycles.

EXERCISES

I. Read fluently:

as a matter of fact, for the sake of simplicity, at a distant transmitting station, a period of activity of a microphone, the high-impedance winding of the telephone receiver, a reproduction of current in the tsansmitting antenna, the e. m. f. impressed upon the receiving antenna, the coupling between the antenna circuit and the closed circuit.

II. Write words of the same stem and translate them:

simple, to use, necessary, to receive, to reproduce, to vary, to suit, to represent, able, to measure, to define, proper, to select, frequent.

III. Translate the following phrases, observing the modal meaning of the verb *will*. Give some examples in sentences:

it will be noted, it will be noticed, it will be appreciated, it will be realized, it will be seen.

IV. Give Russian equivalents for the following terms:

spark receiver, closed circuit, coupling coil, high impedance winding, radio-signal voltage, non-inductive load resistance, response, volume control.

V. Give English equivalents for the following terms:

настраивать, приложенная э. д. с., передающая антенна, приемная антенна, однонаправленный, чувствительность, избирательность, верность воспроизведения, нагрузочное сопротивление, громкость, регулировка громкости.

VI. Put questions to the texts and be ready to answer them.

VII. Retell the first text.

VIII. Write a summary of the second text.

IX. Make a description of your receiver.

X. Define:

a) the sensitivity of a receiver; b) the selectivity; c) the fidelity of a receiver.

XI. Translate into English the summary of the text:

В этом тексте рассматривается простейший приемник. Описывается работа приемного устройства, сконструированного автором. Обсуждается связь между цепью антенны и замкнутым контуром. В этой схеме иллюстрируется усилитель, широко применяемый в области радио и телевидения.

64. Radiation of Electrical Energy

Every electrical circuit carrying alternating current radiates a certain amount of electrical energy in the form of electromagnetic waves, the amount of energy thus radiated being extremely small unless all the dimensions of the current approach the order of magnitude of a wavelength. Thus a power line carrying 60 cycles current with 20 ft. spacing between conductors will radiate practically no energy because of a wavelength at 60 cycles being more than 3000 miles and 20 ft. is negligible in comparison. On the other hand, a coil 20 ft. in diameter and carrying a 2000 kc current will radiate a considerable amount of energy because 20 ft. is comparable with the 150-meter wavelength of the radio wave. The common radio antenna consisting of a vertical wire with a flat-top structure is essentially a condenser in which one plate is the ground, the other one being the flat top. Such an arrangement will be a good radiator of electrical energy when the ratio of height to wavelength is appreciable, i. e., at least 1 : 100, and preferably 1 : 10. Similarly a coil will be a good radiator of electrical energy provided the size of the coil be sufficiently great. The usual loop antenna consists of a coil and will be an efficient radiator to the extent that the ratio of loop diameter to wavelength is appreciable.

It is apparent from above considerations that the size of radiator required is inversely proportional to frequency.

High-frequency waves can therefore be produced by a small radiator, low-frequency waves requiring a high-antenna system for effective radiation. The practical result of this fact is that the antennas of low-frequency transmitting stations are sometimes suspended from towers over 500 ft. high and yet are less efficient radiators than an antenna of one-tenth, this height operating at a very high radio frequency.

Every radiator has directional characteristics as a result of which it sends out stronger waves in certain directions than in others. Thus, while a vertical wire radiates the same amount of energy in directions that are perpendicular to the wire, the radiation in vertical plane varies from a maximum in a horizontal direction to zero in a vertical direction. Directional characteristics of an antenna are taken advantage of to concentrate the radiation toward the point to which it is desirable to transmit.

The amount of energy sent out from any radiating system is proportional to the square of the radio-frequency current that flows in the radiator. Due to all the common sources of radio-frequency energy being relatively low voltage high current sources, it is necessary that the radiating system offer a relatively low impedance to the radio-frequency energy to be transmitted. This is accomplished by tuning the antenna circuit to resonance with the frequency to be radiated, which makes the impedance of the antenna circuit low and enables a relatively small applied voltage to produce a very large antenna current and hence a high radiated energy. This is the only reason for tuning the transmitting antenna, as the mere tuning of the radiating systems to the frequency being transmitted does not increase the radiated power per ampere of current. The tuning is effected by inserting an inductance or a condenser in series with the antenna, as circumstances require. Thus in the flat-top antenna the antenna has a capacity resistance and so is tuned by the use of the inductance coil.

EXERCISES

I. Make a written translation of the last passage of the text.

II. Translate the following words and note the type of word-building:

attenuation, broadcast, somewhat, likewise, straightline, approach, order, hand, flip-flop, airplane, zigzag, sometimes, square, one-tenth.

III. Translate the following words:

favor, favorable, unfavorable; compare, comparison, comparable, incomparable; to continue, continuous, continual, continuity, discontinuity; to appreciate, appreciable, appreciation; to neglect, negligible; apparent, apparently; efficient, inefficient, efficiently, efficiency; certain, certainly, certainty; to be certain; to relate, relative, relatively, relation, relationship; able, ability, to enable; direct, direction, directly, indirectly, directional.

IV. Pick out of the text the technical terms and give their proper translation.

V. Pick out antonymical pairs from the following words:

appreciable, directly, the same, parallel, to transmit, negligible, inversely, to receive, different, to increase, to remove, in series, to reduce, to insert.

VI. Find in the text sentences with:

the Nominative Absolute Participial Construction, Participles in the post-position, complexes with the Gerund, conditional sentences, sentences with the Passive Infinitive used attributively, complex subjects and complex objects with the Infinitives.

VII. Be ready to speak about the radiation of energy according to the plan given below:

1. Radiation of electrical energy by way of electrical circuits carrying alternating current. 2. The common radio antenna as a radiator of electrical energy. 3. The construction of a usual loop antenna. 4. The production of high- and low-frequency waves. 5. The directional characteristics of a radiator. 6. The amount of energy sent out from any radiating system. 7. The tuning of a transmitting antenna.

VIII. Write a summary of the text.

65. Cathode-Ray Tubes

Cathode-ray tubes are widely used in various branches of radio engineering such as oscillography, radiolocation, television, etc. In the narrow part of the tube the cathode K, focussing system and beam-deflecting system are mounted. Deposited on the inner surface of the glass face-plate is a luminiscent screen S. The cathode is of the indirectly heated oxide-coated type. It is fabricated in the form of a cylinder with the oxide coating on its end cap. The cathode is mounted inside a control electrode (modulator) CE in which an aperture is provided. The brightness of the spot on the tube screen can be varied by changing the negative potential on the control electrode with respect to the cathode thus changing the electron-beam current.

Moving along the tube axis after passing the control electrode is the electron stream which encounters two anodes A_1 and A_2, both of which are cylindrical in shape. The accelerating field provided by the two anodes ensures the motion of electrons towards the screen and simultaneously focusses the stream into a narrow beam.

Electron beam focussing can be accomplished with the aid of either an electric or magnetic field. In the first case focussing is termed electrostatic and takes place in the electric field between A_1 and A_2. An electron E moving at some angle to the device axis is deflected by the electric field set up between the anodes. Proper selection of the voltage difference on these electrodes ensures focussing of the beam on one spot on the tube screen.

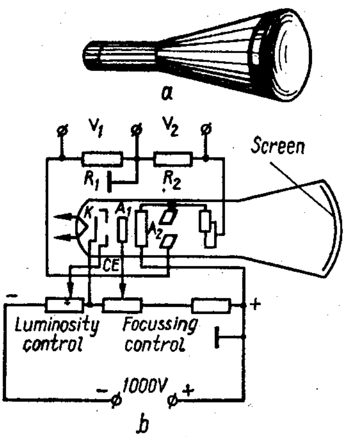

Fig. 19

Magnetic beam focussing is achieved by a focussing coil mounted onto the tube neck.

Deflection of the electron beam is accompanied in the same manner as focussing that is either by an electric field or by a magnetic field. The electrostatic system of beam deflection consists of two pairs of vertical and horizontal deflecting plates. An electron passing between two parallel plates to which a certain voltage is applied, it will be deflected towards the positively charged plate. There being two pairs of mutually normal plates, the electron beam can be deflected in horizontal and vertical planes.

Magnetic field deflection is accomplished by two pairs of deflecting coils mounted onto the tube neck at right angles to each other. The greater the magnetic-field intensity H and the lower the voltage V which accelerates the electrons, the greater is the beam deflection.

The tube screen is a semitransparent thin layer of a luminous substance.

Most cathode-ray tubes are oscilloscopes used to display rapidly changing voltages and currents.

EXERCISES

I. Find in the text synonyms for the following words:

different, to produce, to supply, relative to, at once, to occur, to get, speed, to use.

II. Give the words of the same stem:

to vary, part, indirectly, to pass, acceleration, to deflect, to increase.

III. Translate the following expressions. Use them in sentences of your own:

with respect to, either... or, in the same manner, at right angles, simultaneously.

IV. Translate the following terms:

cathode-ray tubes, the focussing system, beam-deflecting systems, luminiscent screens, the control electrode, the electron beam current, the electron stream, the electron beam focussing, the magnetic beam focussing, the magnetic field deflection, the magnetic field intensity, the beam deflection, the horizontal deflecting plates.

V. Translate into English:

Электронно-лучевые трубки широко используются в различных отраслях радиотехники. По своей конструкции ЭЛТ состоит из катода К, системы фокусировки электронного потока и отклоняющей системы. Изменяя отрицательный потенциал управляющего электрода относительно катода, можно регулировать величину электронного потока и таким образом менять яркость светового пятна на экране.

Фокусирование электронного потока в узкий луч осуществляется с помощью электрического или магнитного поля.

VI. Put questions to the text.

VII. Retell the text according to the following plan:

a) The CRT, its construction and application; b) The adjustment of the electron stream; c) Electron stream focussing into a narrow beam; d) Magnetic and electrostatic beam deflection.

VIII. Explain the principle of a cathode-ray tube operation according to the figure. Speak about the design and circuit arrangement.

IX. Write a summary of the text.

66. The Televisor

The most important element in any television transmitter is the televisor or "pick-up-tube", an instrument used in the broadcasting studio or in the field to convert light images into electric currents. Although many televising systems involving numerous principles have been devised, nearly all of them are to be classified as either mechanical or electronic in nature. Because mechanical systems have proved to be more cumbersome, electronic systems are now used almost exclusively.

The Scanning Process in Television. For years the sending of pictures by wire or radio has been everyday occurrence. The fundamental principle, involved in this process, is known as scanning. Every picture to be transmitted is scanned by an exploring spot which, starting at the top, moves in straight lines over the entire picture.

The exploring spot in any scanning device is so constructed that it generates an electric current proportional to the brightness of its instantaneous position. Such a pulsating current, referred to as the video signal, is transmitted over wires or radio waves to the receiving station. There in a specially designed instrument a reproducing spot, whose brightness is proportional to the video signal amplitude, moves over a viewing screen in a path similar to that of the exploring spot. In this way the reproducing spot reconstructs the original picture.

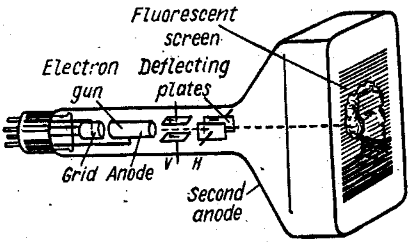

Fig. 20

It will be realized that the smaller the scanning and reproducing spots and the greater the number of lines the better will be the details of the scanned picture being reproduced at the receiving end.

If a single picture is to sent by wire, as is generally the case in the telephotographic newspaper service, the scanning process requires from 10 to 20 min. In television, however, it is a matter of standard practice to scan and transmit thirty distinct and separate pictures every second of time. At the receiving station these pictures are rapidly flashed one after the other upon a viewing screen. All are still pictures differing progressively one from the next so that, due to persistence of vision, the motions seem to be smooth and continuous, just as with moving pictures.

To avoid spurious shadows and images, the process of interlacing is employed. By this process each picture is scanned twice, first by running the exploring spot over the odd numbered lines 1, 3, 5, 7 etc., and then over the even numbered lines 2, 4, 6, 8, etc.

In many respects the apparatus used in television differs very little from that used in radio broadcasting. The varying current from the exploring element of a scanning device, called a televisor, takes the place of the voice currents from a microphone. In other words, instead of modulating the carrier wave of a radio transmitter with the voice currents due to sound waves it is modulated with the video current from the light of a picture image in a televisor. Except for the televisor tube used in the transmitter, and a similar device known as a kinescope used in the receiver, television equipment consists of numerous electrical circuits containing radio tubes similar to those in any radio receiving set.

The Kinescope. In many respects the construction of a television receiver and its operation is similar to an ordinary radio receiver. The carrier wave from a nearby transmitter after being tuned in, detected, and amplified with conventional radio tube circuits, is fed as a video signal into a kinescope in place of a loud-speaker. A kinescope is a large vacuum tube used for scanning and viewing the transmitted pictures.

A kinescope using electrostatic deflection plates for scanning is shown in Figure 20. Electrons from an electron gun at the left travel down the length of the tube to where, impinging upon a fluorescent screen, they produce a bright luminescent spot S. The purpose of the deflecting plates V and H is to deflect the electron beam with the identical frequency and scanning motion of the transmitting station. Two special oscillator tubes and circuits in the receiver supply saw-tooth potentials to these plates, the high-frequency potentials to the H-plates for horizontal scanning and the lower frequency potentials to the V-plates for vertical scanning.

The proper fluctuations in the intensity of the luminescent spot are brought about by applying the video signal to the grid of the electron gun. This grid controls the flow of electrons through to the anode in the same way that the grid controls the current to the plate in an ordinary three-element radio tube.

For a small fraction of a second, between successive pictures being scanned for transmission, current pulses of a certain type and frequency are sent out from the sending station as part of the video signal. These, picked up by the receiver, act as a trigger-like mechanism to bring the reproducing spot to the top left of the screen at the proper time to start the next picture. In other words, the transmitter sends out signals that enable the receiver to automatically keep "in step" with the pictures as they are sent.

EXERCISES

I. Read the following words:

a) with the stress on the first syllable:

to televise, to broadcast, image, to classify, cumbersome, amplitude, similar, realize, detail;

b) with the stress on the second syllable:

to devise, to occur, to explore, proportional, progressive, persistence;

c) with the main stress on the third syllable:

fundamental, reproduce, instantaneous, interlace.

II. Translate and memorize the following word combinations; illustrate their use in sentences:

except for, due to, it is a matter of common practice, it is a matter of common observation; it is a matter of common knowledge; as is generally the case, just as, to take place, to take the place, in place of; with respect to, with regard to, without regard to, irrespective of, irrespectively, regardless of.

III. Find in the text synonyms for the following words and word combinations:

significant, though, almost, to be called, particularly, to understand, to be made up of, standard, initial, minute, movement, to give rise to, in the same manner.

IV. Find in the text antonyms for the following words:

bottom, to receive, similar, odd, rough, much, dull, right, to disable.

V. Make nouns from the following words:

important, to know, to explore, to occur, bright, to require, to differ, certain, similar.

VI. Translate the following sentences, paying attention to the different meanings of the words in italics:

1. The theory *involved* in the operation of the wattmeter is explained in any text on alternating current measurements. 2. When distorted voltages and currents *are involved* the power factor must be thought of as simply the ratio of the wattmeter reading to the product of the voltmeter and ammeter reading. 3. The problem *being* rather *involved*, a thorough research has been made in order to solve it. 4. Theoretical explanations and examples are given to illustrate the principles *involved*. 4. In analog computers measurement *is* always *involved*. 5. That type of construction requires a minimum floor space in proportion to the amount of apparatus *involved*.

VII. Translate and memorize the following terms:

scanning, video-signal amplitude, viewing screen, exploring spot, interlacing, deflection plates, saw-tooth potential.

VIII. Be ready to answer the following questions:

1. What is the most important element in any television transmitter? 2. How can all the televising systems be classified? 3. What is the fundamental principle of sending pictures by wire or radio? 4. What do you know about the scanning and reproducing spots? 5. What is the process of interlacing employed for? 6. What is the difference between the apparatus used in television and that used in radio broadcasting? 7. What special kinds of equipment does a televisor consist of?

IX. Retell the text "The Televisor".

X. Describe the diagram of a kinescope.

XI. Translate into English:

Самой важной частью телевизионного передатчика является телевизионная камера. Этот прибор служит для преобразования световых изображений в электрические токи. Основным принципом процесса передачи изображений по радио является развертка. Видео-сигнал передается на приемную станцию. В телевидении каждую секунду развертывают и передают тридцать отдельных изображений. Чтобы избежать паразитных изображений используют процесс чередования. Во многих отношениях аппаратура, используемая в телевидении, мало отличается от аппаратуры, применяемой в радиовещании.

67. Television in Full Color

To produce television pictures in full color the additive method of color mixing is employed.

Several all-electronic color television receivers have been invented in recent years. Instead of the fluorescent screen being coated with one fluorescent pigment as in the black and white tubes, a separate flat glass plate just inside the large end of the tube becomes the screen and is coated with three fluorescent pigments. These three pigments R, G and B, under electron bombardment fluoresce with the additive primary colours: red, green, and blue, respectively. These fluors are painted on the glass in the form of hundreds of narrow vertical ribbons.

About one quarter of an inch beyond the fluorescent screen, and electrically insulated from it, are about 400 fine equally spaced wires mounted parallel to and with twice the spacing as the color fluor lines. With alternate wires at about +4200 and +4800 volts respectively, and the screen at about 18,000 volts, the narrow incoming beam is brought to a focus.

The beam from the single electron gun sweeping across the screen several hundred times in a fraction of a second, scans and produces a green picture. The wire potentials being reversed, the electron beam sweeping across the screen is brought to focus on only the blue fluor stripes and produces an all blue picture. When the wires are all automatically switched to the same potential (+4500 volts) the electrons are brought to a focus on the red stripes midway between the wires, and the beam "paints" an all red picture. By controlling the electron beam intensity from the gun all colors can be produced. A yellow object being televised, for example, will appear in both red and green pictures but not in the blue picture. A short distance away the eye blends the additive mixture as yellow.

The scanning method of presenting a complete blue picture, followed by a complete green picture, and then a complete red picture, is called field-sequential-scanning. This is to be distinguished from a line-sequential-scanning process in which first a blue line, then a green line, and then a red line are presented at the top of the picture, followed by another blue, then a green, and another red line, and so on down the screen.

The "chromator" is also capable of dot-sequential scanning, a process in which sequences of dots are presented in rapid succession; a blue dot, then a green dot, then a red dot, then a blue, then a green, then a red, etc., filling up each line in turn and each entire picture frame with colored dots.

EXERCISES

I. Memorize the following terms:

spacing — интервал, расстояние, разнос; intensity — напряженность; field-sequential scanning — с последовательным чередованием полей; line-sequential scanning — с последовательным чередованием строк; dot-sequential scanning — с последовательным чередованием точек.

II. Analyse the Present Participles in the text and translate them properly.

III. Make up a plan of the text.

IV. Retell the text according to your plan.

V. Make a short report about the principle of colored television and its development.

VI. Write a summary of the text.

Part V

AUTOMATION. CYBERNETICS. COMPUTING TECHNIQUE

68. Automation and Mankind

Quite recently automation control was considered as just one of the many means for developing technological processes, having only limited, partial importance. Even the words "Automatic Control" and "Automation" did not appear at that time on the pages of the world press, with the exception of the Soviet press. But in the early forties, the position completely changed. Automatic control is now recognized throughout the world as a new, independent branch of science and engineering. More than that, automatic control enters the world arena and takes by right, on account of its importance, an equal place in the field of science with new techniques such as nuclear energy, radio-electronics, and astronautics.

This can be explained by the enormous possibilities provided by automatic control for the development of modern technique. Complex mechanization of production, by releasing man from heavy physical labour and replacing his work by that of mechanisms and machines, increases the productivity and prepares the ground for the following high stage — the complex automation of production. Modern automata are able to release man in many instances from brain activity and, therefore, enable him to economize his forces for the creative processes.

Automation, by increasing productivity, contributes to a marked increase of material wealth, and to a solution of the problem of a substantial increase in the standard of living of mankind. Automation contributes to the obliteration of the frontiers separating brain work from physical labour, creating a basis for an unusual cultural flowering and an increase of the intellectual level of man.

Automation has revolutionized the majority of manufacturing techniques as it provides for control of industrial processes which occur at extremely high rates and on a large scale.

The full utilization of the benefits arising out of automation, however, is only possible in a rationally organized society. This possibility is offered by the socialist system.

EXERCISES

I. Read the following words with due attention being paid to the stress and pronunciation:

partial, wealth, health, weather, separate, control, exception, enormous, technology, technological.

II. Find in the text synonyms for:

fully, all over the world, tremendous, to free, hence, to take place.

III. Make nouns from the following verbs:

to recognize, to depend, to increase, to produce, to solve, to mean.

IV. Memorize the following word groups and compose sentences with them;

throughout the world, on account of, to provide, to a marked degree.

V. Put questions to the text and be ready to answer them.

VI. Be prepared to speak on:

1. The USSR — the pioneer in the field of automatic control. 2. The place automatic control occupies in science and technique. 3. Automation and labour productivity. 4. Automation obliterates the frontiers separating brain work from physical labour.

69. Age of Thinking Machines

It goes without saying[28] that the electronic computer is one of the most remarkable achievements of the 20th century, which marked the emergence of man into the era of automation of mental work. The following trends in the development of electronic computation may be defined according to Soviet Academician Viktor Glushkov.

Firstly, an increase in the volume of the machine memory. The memory system of the future machines will store the entire wealth of knowledge accumulated by man in all the sciences, in culture and in every aspect of human life, the potential in this field being infinite.

Secondly, microminiaturization. This is associated with the progress of radio electronics. In the designing of electronic computers we have passed from radio valves to transistors, which are smaller in size, and recently to solid circuits, where various portions of a tiny piece of synthetic crystal are imparted the necessary electro-physical properties by appropriate treatments.

Microminiaturization is found to make it possible to construct extremely complex computers of small size and weight, but consisting of a tremendous number of elements.

The electronic machines will affect radically the work of scientists. In effect, the machine will by itself accumulate, process and supply new data. By this method some new types of codes have been found, their discovery necessitating the testing and comparisons of approximately one thousand million operations. Thanks to the high rate of processing the computers have found new codes independently.

EXERCISES

I. Read the following words with the stress on the first and the second syllable:

1) 'wealth, 'mental, 'increase, 'aspect, 'infinite;
2) ac'cumulate, as'sociate, ap'propriate, syn'thetic, ne'cessitate.

II. Find in the text synonyms for:

to determine, dimension, very small, tube, velocity.

III. Find in the text the sentences with the following grammar forms and give their proper translation:

1. Complex subject with the Infinitive.
2. Complex object with the Infinitive.
3. Nominative Absolute Participial Construction.
4. Participles used attributively.

IV. Translate the following sentences with the expressions in italics:

1. *It goes without saying* that we live in the age of cybernetics and automation. *It goes without saying* that computers will radically change the work of man. 3. Scientists can *draw* many *conclusions from* the data obtained. 4. *In effect,* we know water to boil at the temperature of 100° C. 5. *It is common knowledge* that computers are of great help in mental work. 6. That water boils when sufficiently heated is *common knowledge.*

V. Memorize the following terms:

memory system — запоминающая система; to store — хранить, запоминать; to process — обрабатывать; treatment — обработка.

VI. Make up a plan of the text.

VII. Retell the text according to the plan.

VIII. Translate this summary of the text, paying attention to the place of the predicate in English and its corresponding place in Russian:

The development of electronic computation is described in this text. The trends in its development are shown. The new possibilities microminiaturization opens for the scientists are considered.

70. Cybernetics

Cybernetics is hard to define. The word «cybernetics» is known to have originated from the Greek κυβερνητική (τέχνη) — meaning control. Cybernetics was defined by Wiener as «the science of control and communication, in the animal and the machine», coordination, regulation and control being its themes.

Scientists know cybernetics to be a theory of «machines», but it treats not things but ways of behaving. It does not ask «What is this thing?» but «What does it do?»

Cybernetics started by being closely associated in many ways with physics. It deals with all forms of «behaviour» in so far as they are regular, or determinate or reproducible. It takes as its subject-matter the domain of «all possible machines». What cybernetics offers is the framework on which all individual machines may be ordered, related and understood. It is known to have found many applications in different fields of science, technique and economics. *It should be kept in mind*[29] that it offers a single vocabulary and single set of concepts suitable for representing the most diverse types of systems.

Cybernetics offers one set of correspondences with each branch of science, can thereby bring them into exact relation with one another.

It has been found repeatedly in science that the discovery that two branches are related leads to each branch helping in the development of the other, the result being often a markedly accelerated growth of both. The infinitesimal calculus and astronomy, the virus and the protein molecules are examples that come to mind. Cybernetics is likely to reveal a great number of interesting and suggestive parallelisms between machine and brain and society. It can provide the common language by which discoveries in one branch can readily be made use of in the others.

Thus, cybernetics provides effective methods for the study, and control of systems that are intrinsically extremely complex. One of the functions of cybernetics is to study the new techniques that are needed in order to enable the scientists to cope with the increasingly complex problems. It deals with ways of making machines; computers and systems operate similarly to the human brain or other biological systems in spite of the brain's being far more efficient than computers in solving certain problems.

EXERCISES

I. Read the following words with the proper stress:

originate, associate, intelligent, accelerate, diverse, suitable, intellectual, infinitesimal, example, sample, science, society, suggestive, parallelism.

II. Make up sentences using the following:

closely associated, in many ways, in so far as, it should be kept in mind, thereby, to be likely to, to make use of, in spite of, just as, to solve a problem.

III. Make up all possible words of the same stem:

to find, difficult, able, strong, to compute, to discover, ready, close, to increase, similar, to solve, to adjust, to provide.

IV. Make a written translation of the third passage of the text — from "Cybernetics started..." to the words: "... diverse types of systems".

V. Answer the following questions:

1. What does the word "cybernetics" originate from? 2. How was cybernetics defined by Wiener? 3. What does it deal with? 4. What does it offer? 5. Where has cybernetics found many applications?

VI. Retell the text.

VII. Write a summary of the text.

71. Machine Language and Language Structure

A digital computer is composed of five functional units, each performing its own function. A machine language is needed for each functional unit to communicate with the others. This same language is required by man to instruct the machine what to do. Man translates his problems into machine language by means of a program of instructions.

The language structure of a digital computer is fairly simple. Bits are encoded into digits or characters which are, in turn, encoded into words. There are two kinds of words, the instruction word and the data word. The instruction word is active. It operates upon the passive data word, a group of instruction words forming a program.

In general the instruction word consists of two parts: the command portion and the address portion. The command specifies the operation to be performed by the machine. The address portion specifies the location where the operand or operands are stored.

Most of the operations of the computer are performed in the automatic unit. The command portion of the instruction causes the arithmetic unit to perform addition, subtraction, multiplication, division, square root; or to bring operands into the arithmetic unit; or to remove results from the arithmetic unit. Some commands rearrange the information stored in the arithmetic registers. Other commands allow the computer to choose among different sets of instructions according to some criterion such as whether the result of a previous operation is positive or negative.

The other part of the instruction word is the address. Instruction codes differ significantly according to the number of addresses specified by the instruction. One-, two-, three- and four-addresses instructions have been used in digital computers. These instructions are described in the following.

One-Address Instruction. When only one address is specified, the machine executes the given command upon the operand found in the location specified by the address. Since most arithmetic operations require at least two operands — augend and addend, multiplicand and multiplier — the computer must be built so that one operand is brought into the arithmetic unit during one instruction, and the other operand is brought into the arithmetic unit during the following instruction; during the second instruction the arithmetic operation is performed. The sequencing of the instruction words in the program is performed by a program counter. As soon as one instruction is completed, *the program counter is advanced by one*[30]. The new reading of the program counter specifies the address of the next instruction to be executed. The machine thus automatically chooses instructions stored in successive memory locations.

Two-Address Instruction. The two-address instruction consists of a command, an address, specifying the operand, and an address specifying the location of the next instruction word to be executed. The two-address-instruction machine does not need a program counter.

Three-Address Instruction. The three-address instruction consists of a command and three addresses. The first two addresses specify two operands; the third address specifies the location in memory where the result should be stored. Machines using the three-address instruction need a program counter to sequence instructions in the program.

Four-Address Instruction. The four-address instruction has a command and four addresses. The first two addresses specify two operands. The third address specifies the location of the result. The fourth address indicates the location of the next instruction to be executed. Machines using the four-address instruction need no program counter.

The above descriptions are true for the majority of computers. However, computers have been built which interpret their address codes differently.

EXERCISES

I. Read fluently:

digital computer, functional unit, machine language, language structure, instruction word, the command portion, arithmetic unit, the sequence of the instruction words, during the following instruction, as soon as the instruction is completed, chooses instructions stored, the two-address instruction, the first two addresses specify, where the result should be stored.

II. Find in the text synonyms for:

to consist of, to do, to demand, sufficiently, to permit, various, to finish, to show, most of.

III. Find in the text the sentences with different ways of expressing obligation.

IV. Note the different functions of the Infinitive in the following sentences:

1. Machines using the three-address instruction need a program counter to sequence instructions in the program. 2. The fourth address indicates the location of the next instruction to be executed. 3. Other commands allow the computer to choose among different sets of instructions according to some criterion. 4. To distinguish between minus and positive exponents, a special characteristic encoding system may be used in decimal machines. 5. To increase the reliability of the computer, words are periodically fed through checking circuits. 6. The force causing current to flow is to be measured with the instrument under consideration. 7. This system appears to possess many advantages. 8. The machine can be made to detect the error.

V. Memorize the meanings of the following special terms:

digital computer, bit, operand, augend, multiplier, address code, counter, memory location.

VI. Find in the text Russian equivalents for:

in its turn, according to, since, in this way, the above.

VII. Answer the following questions:

1. What functional units is a digital computer composed of? 2. How does man translate his problem into machine language? 3. How are bits encoded? 4. What kinds of words are used for digital computers? 5. What parts does the instruction word consist of? 6. Where are most of the operations of the computer performed? 7. What does the command portion of the instruction cause the arithmetic unit to perform? 8. How do instruction codes differ?

VIII. Be ready to speak about:

1) one-address instruction; 2) two-address instruction; 3) three-address instruction; 4) four-address instruction.

IX. Be ready to speak about machine language.

X. Write a summary of the text.

72. Algorithm

The simplest mathematical operation is addition. It can be carried out without any understanding how it works, simply by obeying certain rules best exemplified by the use of the abacus:

«Move to the right the number of beads corresponding to the number of units of the first figure. Then move to the right the number of beads equal to the number of units of the second figure. Count the total number of beads for the requisite sum». Using these rules a first-former at school can add one-digit numbers with the help of an abacus. Only in mathematics instead of «rule» they say «algorithm». If a problem is likened to a lock, then the algorithm for its solution is the key. Algorithms are needed to solve diverse problems. The solution of the most difficult problem can be broken down into a number of simple operations, a sequence of elementary steps. They are described by an algorithm.

Thus, an algorithm is a precise instruction for solving a class of problems by means of a series of simple operations. In other words, it is a manual for problem-solving. An algorithm is a faithful guide that shows the road to be followed to solve a problem.

As a guide to action every algorithm must meet certain requirements. Thus, it must be applicable not for the solution of just one problem, but of all problems of a given type.

Discovering and formulating an algorithm requires extensive knowledge and much hard creative work.

But the algorithm having been found and the problem solution broken down into an ordered sequence of precisely defined operations, all that remains is to faithfully carry out the instructions.

Nowadays scientists have learned to automate the solution of any problem for which an algorithm exists. Practically every new algorithm means new solutions of problems. The simpler and shorter an algorithm, the shorter is the road to the solution of the mathematical mysteries concealed behind formulae and equations.

Algorithms are of prime importance in computer mathematics — in fact, they are computer mathematics.

The greater the advances of computer mathematics and the more wide spread the use of computers in all spheres of life, the more important is the task of discovering algorithms for solving large series of problems. With such an algorithm a computer can be programmed so that it can solve any or all of the problems of the series, as the case may require.

The importance of comprehensive algorithms is enhanced by the fact that computers calculate very swiftly and in time will work even faster.

EXERCISES

I. Read with proper stress:

physics, sphere, widespread; extensive, creative; precise, conceal; enhance, exemplify.

II. Read fluently:

a number of operations, a series of simple operations, a sequence of elementary steps, an ordered sequence of precisely defined operations, for solving a class of problems, a manual for problem-solving.

III. Make all derivatives you know from:

equal, to know, precise, to add, to solve, to require, to apply.

IV. Find in the text synonyms for:

exact, to meet the demands, to determine, at present, to increase, fast.

V. Find in the text:

1) the Infinitive and state its functions;
2) the Nominative Absolute Construction.

VI. Translate the following sentences:

1. The greater the advances of computer mathematics, the more important is the task of discovering algorithms. 2. The simpler and shorter an algorithm, the shorter is the road to the solution of the mathematical mysteries. 3. The greater the programme file for the computer, the greater is its value. 4. The more elements the memory blocks contain, the higher is the probability of their failure.

VII. Answer the following questions:

1. What is the simplest mathematical operation? 2. What are algorithms needed for? 3. What is an algorithm? 4. What requirements must it meet? 5. Where are algorithms of prime importance? 6. What does formulating an algorithm require? 7. What fact enhances the importance of comprehensive algorithms?

VIII. Retell the text.

IX. Translate into English:

Решение самых трудных задач может быть разделено на ряд простых операций. Они описываются посредством алгоритма. Алгоритм является руководством, которое указывает путь к решению задач. Он должен быть пригодным для решения всех задач данного типа. В настоящее время ученые научились автоматизировать решение любых задач, для которых имеется алгоритм. Чем развитее вычислительная математика, тем важнее задача разработки алгоритмов для решения большого ряда задач.

73. Programming

Any problem is expressed in purely mathematical terms. It contains formulae, equations, calculations. But the problem is for the computer a thing beyond its understanding. The computer cannot handle formulae, equations or calculations. The computer does not know what man asks of it. The programmist is the connecting link between the computer and the problem it has to solve. He has first to visualize then to subdivide any complex problem into a sequence of simple instructions that the computer could cope with. He has to realize in the computer all information transmission routes necessary for the execution of a certain sequence of operations.

Every problem, even the simplest one, contains numerous instructions. Naturally, the more complicated is the problem, the longer is the list of instructions. The compilation of programmes is a very difficult job requiring high qualification. When the problem is compiled and laid into the computer, the latter sets to work. The purpose of the programme is to provide instructions for the opening of a certain group of valves while keeping the others closed. The work of the computer is governed by the control block, the main element of the computer. This block exercises control over different parts of the computer, tells each part when it should go into action, what and how it should do. The control block concentrates in itself all the internal communications and "processes", all commands which control such a complex automation as the high-speed electronic computer.

The operator switches on the computer and inserts a programme containing a list of instructions that have to be performed in sequence in order to solve the programme. The programme in a computer is executed in sequence — in cycles, step by step — operation after operation.

An instruction has been received by the control device. It immediately "opens" the appropriate group of valves and makes the computer carry out the instruction.

Suppose the instruction is: add the number in register B to the number in register A, send the sum to register C. Other valves will be needed for subtraction, etc.

The computer should open the group of valves which transmit numbers over the adder.

Each instruction consists of two parts: it tells "what to do" and "where to do it"— the operation and the address part or simply address.

Without the programme the electronic computers, even those capable of millions of operations per second are, at best, merely items of furniture of institute and factory offices. The entire line of calculations in the computer, the so-called processing of information from input to output, is organized by the programme. It's the programme that ensures the execution of all operations assigned to the computer.

The programmists prepare whole series of standard programmes for the solution of typical problems. The greater the problem file provided for the computer the better it is adapted for work, the easier is its contact with the user, the greater are the facilities for its use and the greater is its value.

Programme compilation has become a sort of an industry for the mathematical provision of computers. This mathematical provision is a complex — literally a multitude — of programmes compiled in special libraries. They enable the computer to operate efficiently, to carry out the solution of programmes.

Those who think of becoming programmists should study mathematics thoroughly.

EXERCISES

I. Read the following words:

a) to visualize, to realize, to equalize, to exercise; to subtract, to subdivide; facility, applicability, reliability; execution, distribution, contribution;

b) to process, process; to progress, progress; to subject, subject; to object, object.

II. Read fluently:

a thing beyond its understanding, man asks of it, a sequence o simple instructions, the processing of information, a whole series o standard programmes, that the computer could cope with, a very difficult job requiring high qualification, while keeping the others closed, the main element of the computer, over different parts of the computer, the appropriate group of valves, to transmit numbers over the adder, the entire line of calculations, whole series of standard programmes, the facilities for its use.

III. Memorize the following terms:

the compilation of a programme, the execution of a sequence of operations; the computer is governed by the control block, the process, the information, from input to output, the programme file, mathematical provision.

IV. Give words of the same stem:

to add, to execute, to exercise, to solve, to provide, to subtract, efficient.

V. Translate the following sentences with emphatic inversion:

1. It is the programme that ensures the execution of all operations assigned to the computer. 2. It is the programmist that is the connecting link between the computer and the problem it has to solve. 3. It was not until the 20th century that electronic computers were constructed and put into operation. 4. It was in 1944 when the first relay machine capable of adding two 23-digit numbers in 0.3 sec was completed.

VI. Make up a plan of the text.

VII. Retell the text according to your plan.

74. Universal Electronic Computer

Without calculating machines normal life of modern society and continued progress in science and technology would be impossible. But even with the aid of mechanical, non-electronic calculating machines people nowadays are no longer able to deal with extremely complicated problems posed by modern life. This led to the appearance of electronic computers some twenty years ago.

At present the electronic computer became the most powerful calculating instrument. Electronic computers do deal instantly with a flood of numbers.

Unbelievably high speed of count is only one of the extraordinary properties of the marvelous machine, which can extract roots, integrate and solve the simplest algebraic equations as well as the most complex differential equations.

Machine tools, shops and factories are controlled by computers. There are computers that do the work of engineers, translators, teachers, etc.

DIALOGUE

D e m o n s t r a t o r: Let's have a talk about this most interesting machine. Can't you tell us how numbers enter the computer?

S t u d e n t: They enter the computer by way of the coding device. Here numbers and instructions undergo transformation and assume the form suitable for computer operation.

D e m o n s t r a t o r: Well, do all the numbers remain here?

S t u d e n t: Some of the numbers remain here for a time being inactive. For the others the working store plays the part of a transit station. Through the transit station some numbers reach the permanent "memory", where they are stored by millions, the time of storage being unlimited.

D e m o n s t r a t o r: That's right. And what about other numbers?

S t u d e n t: Other numbers are needed for immediate processing, and they are instantly fed into the arithmetic unit, consisting of adders, multiplication, division and subtraction circuits.

D e m o n s t r a t o r: What kinds of "memory" does the electronic computer possess?

S t u d e n t: In addition to permanent, long-time "memory" the electronic computer possesses a working "memory" as well. This "memory" is needed to record data frequently used in the course of work.

D e m o n s t r a t o r: Is the capacity of the working "memory" large?

S t u d e n t: No, it is not very large, but it hands out numbers quickly (at short notice).

D e m o n s t r a t o r: In what way is the ultimate result of the calculations — the finished product of the computer — obtained?

S t u d e n t: The finished product enters the output block and is typed on paper tape or on blanks of a specified form.

D e m o n s t r a t o r: How does the computer work?

S t u d e n t: The computer works in separate cycles. The control block is the most important part of the computer, for it is due to this block that automatic operation of the calculating blocks is possible.

D e m o n s t r a t o r: Where are the instructions transmitted?

S t u d e n t: The instruction from the working "memory" is transmitted to the control block. It is recorded here and carried out during the next cycle. The process is repetitive: choice of an instruction — execution. The execution of the prescribed computer programme consists of a great number of such repetitions.

EXERCISES

I. Make nouns from the following words:
assume, absorb, store, add, divide, multiply, to record, to increase, to prescribe, to choose, possible.

II. Find in the text synonyms for:
constant, help, often, rapidly, to get, to fulfil, to be made up of, to take place, to stay, to suppose.

III. Find in the text sentences with emphatic *do*. Translate it properly.

IV. Memorize the following terms:
digital computer, working memory store, transit station, permanent memory, long time memory, to process, processing arithmetic unit, adder, to record, choice, execution.

V. Translate the following sentences, memorizing the word groups and expressions in italics:
1. It is very important to know the time the current passes the midway between the given points because of its being *of great importance* for the problem *in question*. 2. A considerable amount of heat is radiated by the body *in question*. 3. It is apparent that a gas or vapour will be liquified by any pressure which exceeds the vapour pressure of the liquid at the temperature *in question*. 4. Organic chemistry now includes some hundred thousand compounds, *for the most part* artificial products of the laboratory. 5. The reactions used in analytical chemistry are *for the most part* between electrolytes and are usually carried out at specified ion concentrations. 6. *The heavier* the substance, *the more complicated* is the atom. 7. *The higher* the current flow, due to a higher voltage, *the greater* is the number of electron collisions per second. 8. *The higher* the resistance of the wire, *the hotter* it will get under the flow of a given current. 9. *The more* the load resistance is increased, *the less* becomes the total amount of power involved. 10. *The faster* the wire moves, and the stronger the field through which it moves, *the greater* is the induced e. m. f. and the resultant electric current. 11. In an inductive circuit *the greater* the inductance, *the longer* will be the delay.

VI. Translate the following questions into English and answer them:

1. Как числа поступают в компютер? 2. Что там происходит с числами и инструкциями? 3. Куда числа передаются? 4. Куда подаются другие числа для немедленной обработки? 5. Какого вида

память имеется в компютере? 6. Каким образом получается окончательный продукт? 7. Как работает компютер?

VII. Describe the block-diagram.

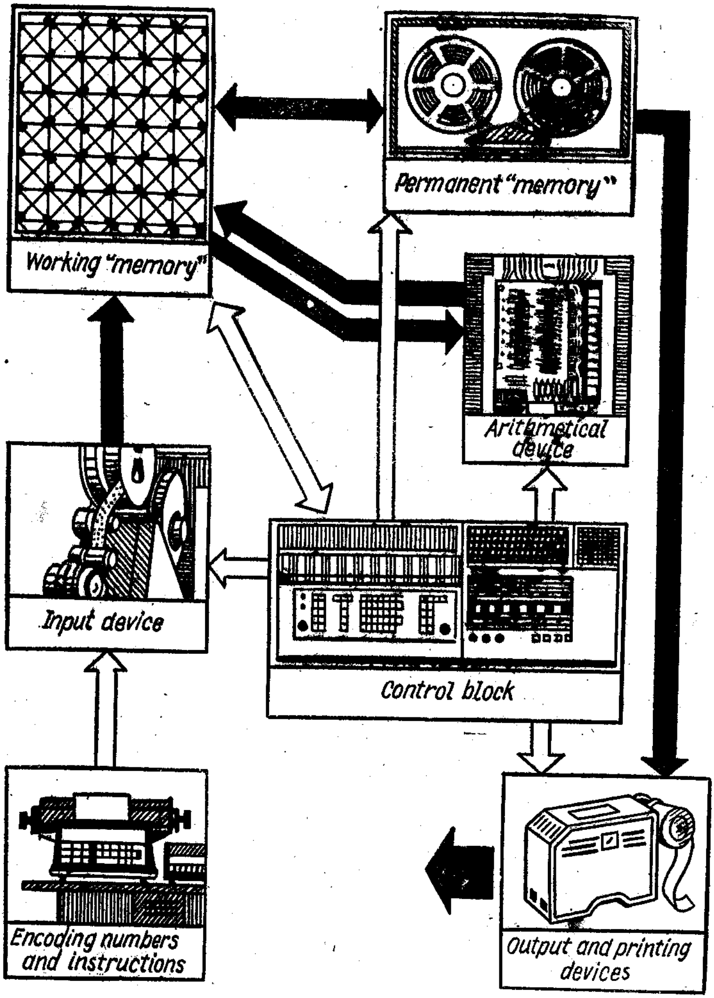

Fig. 21

VIII. Retell the text.

75. General- and Special-Purpose Computers

The general-purpose computer is a machine capable of performing many different kinds of problems. It is sufficiently flexible so that it can communicate with all parts of the machine. It can execute a long list of instructions. A program may be prepared at will, stored in the memory, and then executed.

Not so with the special-purpose computer. As its name implies, the special-purpose computer is built to perform only one job or a group of special jobs, internal communication being restricted. It may possess a shorter instruction repertoire. Its program may be fixed; in other words, the same sequence of events may occur during a repetitive cycle.

The advantage of a general-purpose computer is that it can be programmed to perform many different problems, being flexible enough. The advantage of the special-purpose computer is that *it can be tailored to do a specific job*[31] in the most straightforward way.

Most computers are neither completely general-purpose machines nor completely special-purpose machines. Many so-called general-purpose computers are known to have features which restrict their use to certain general problem areas. The programs of many special-purpose computers may be modified by switches on the control panel, by plugboards, or by other means.

The general-purpose machine is as a rule more complicated. It should be easy to apply the principles of general-purpose machines to the understanding of special-purpose machines.

EXERCISES

I. Read the following with due attention being paid to fluent reading, stresses and pronunciation:

the programs of a special-purpose computer, the advantage of a digital computer, the sequence of events, one job or a group of special jobs, a program prepared at will, all parts of the machine, a machine capable of performing different kinds of problems, it is sufficiently flexible.

II. Form derivatives of the following words:

perform, capable, execute, communicate, memory, differ.

III. Write synonyms to:

different, kind, job, perform, occur, way, completely, purpose, sufficiently, to restrict.

IV. Mind different meanings of the following words:

problem, list, as, performance, event, kind.

V. Write sentences making use of the expressions given below:

at will, neither ... nor, in other words, by different means, as the name implies.

VI. Write out of the text all terms referring to computing technique.

VII. Write questions to the text and be ready to answer them.

VIII. Tell about general- and special-purpose computers.

IX. Translate into English:

Компютер общего назначения является машиной, способной выполнять много различных инструкций. Компютер особого назначения может выполнять только одну работу. Его внутренняя связь ограничена. Программы для них могут модифицироваться посредством ключей на контрольной панели. ЭВМ особого назначения менее сложна, чем ЭВМ общего назначения.

76. Digital Computers

The desk calculator is an example of a class of devices operating as digital computers, where the input and output are numerical digits in contrast to the analog computer, in which the input and output are physical quantities. The desk calculator performs various arithmetical operations largely through an ability to add or subtract, the human operator directing, or programming the machine in such a way that through a sequence of additions or subtractions many more complex arithmetical operations are performed.

Assuming proper machine operation, the accuracy of a digital computer is dependent only on the number of significant digits carried through the computation, this number being largely fixed by questions of allowable complexity and cost of the machine. Human reading error and component calibration are largely eliminated by the digital form of the result. During the period 1944 to 1947 several computers were built which sought to improve the speed of operation through the use of electrical relays as operating elements with the binary system of arithmetic, to which the relays lent themselves through their two state open or closed form of operation. Numbers were handled in binary form as chains of electrical pulses representing 1s and Os in proper sequence.

The first relay machine, completed in 1944, was capable of adding two 23-digit (decimal equivalent) numbers in 0.3 sec, thus materially exceeding the speed of a desk calculator, which is of the order of two 10-digit additions per minute, including time to record the result.

Further increases in operating speed were obtained by application of the electron tube to replace the relay, it being realized that the flip-flop circuit was well suited to such numerical computation in binary numbers. With the flip-flop and certain other circuits it is possible to build an electronic digital computer capable of the usual arithmetic operations at high speeds.

The various forms of electronic digital computers operate, in general, by principles which parallel the usual numerical methods, and essentially by processes of addition or subtraction. They employ well known methods of successive approximation or iteration to achieve interpolation, function values, integration, and the solution of systems of differential and algebraic equations. The pulse lengths employed with the binary numbers vary from a few microseconds to fractions of a microsecond.

EXERCISES

I. Read fluently with special attention paid to stresses and pronunciation:

through a sequence of additions or subtractions, the accuracy of a digital computer, the number of significant digits, questions of allowable complexity and cost of the machine, the speed of operation through the use of electrical relays, operating elements with the binary system of arithmetic exceeding the speed of a desk calculator, an electronic digital computer capable of the usual arithmetic operations, the various forms of electronic digital computers, well known methods of successive approximation, the solution of systems of differential and algebraic equations.

II. Form derivatives from the following words:

calculate, number, able, add, subtract, human, accurate, depend, assume, allow, complex, handle, present, equal, exceed, include, real, solve, long, approximate.

III. Write synonyms to the following words:

example, various, accurate, allow, through, materially, obtain, suit, certain, usual, value, achieve, vary, employ.

IV. Illustrate different meanings of the following words in sentences:

proper, through, handle, since, as about.

V. Make up sentences using the following:

in contrast to, in such a way, to be capable of, largely.

VI. Find Participles in the text and state their function.

VII. Write some questions to the text and answer them.

VIII. Be ready to speak about digital and analog computers.

77. Analog Versus Digital Computers

Even before the advent of the electronic digital computer, the analog computer was busy doing important jobs which could not be performed by desk calculators. For instance, instead of building a costly experimental model of an airplane and then running exhaustive wind-tunnel test, the whole "experiment" can be performed by the analog computer. Instead of using an actual airplane, design data for an airplane are fed into the analog computer. Instead of using a wind tunnel, formulas representing the effects produced by varying flight conditions are fed into the computer. The output of the analog computer is usually a curve representing results for a complete set of conditions. Effectively, the tests are performed without any hardware. Upon completion of one "experiment", the computer is ready to perform a new "experiment".

What exactly is an analog computer? or, more fundamentally, an analog device? An analog device is any device whose operation is analogous to some physical quantity we want to measure. A thermometer is a simple analog device. It compares, or draws an analogy, between the expansion of mercury and temperature. A simple spring balance is another analog device. It compares the weight of an object with the force necessary to move a spring.

If an analogy can be formed between the operation of a device and a mathematical process, this device can form the basis for an analog computer. Many physical phenomena may be used to construct analog computers. But since electrons are so mobile, most present-day analog computers perform mathematical operations with the aid of electronic circuits. Electronic circuits have been built which perform operations analogous to those of addition, subtraction, multiplication, division, and even higher mathematical operations such as integration. For instance, to add 6 and 5, a 6-volt signal and a 5-volt signal are fed to an electronic adder. The circuit of the electronic adder is designed so that under these circumstances an 11-volt signal is produced as output.

Similar effects occur with the subtractor, multiplier, divider, and integrator.

Notice that in analog computers, measurement is always involved; in digital computers, numbers are used. Data in analog computers change smoothly; data in digital computers change in discrete steps. Analog computer results must be read off a scale. Results of digital computation are given by means of a representation for the digits of the number.

There is a limit to the accuracy obtainable from an analog computer. This is so because there is a limit to the accuracy with which one can read a scale. The scale can be enlarged to increase the available accuracy. But even if this is done, the accuracy of the electronic circuits feeding the scale must be improved. Eventually the point is reached where it is difficult, if not impossible, to improve greatly the available accuracy.

However, the accuracy obtainable from a digital computer is theoretically unlimited. This is so because a separate circuit takes care of each column in a set of figures. Thus, 5 adders are needed to add a 5-digit number to another 5-digit number, and 50 adders are needed to add a 50-digit number to another 50-digit number. Theoretically, therefore, we can obtain answers accurate to any decimal place by merely providing the appropriate number of circuits.

The digital computer is extremely fast, but it has the "brains" of a moron. Basically all the machine can do is to add. If this is true, how can the computer perform problems in higher mathematics? The answer to this question is that for a respectable number of problems no matter how sophisticated they may appear, they can be shown to be related to addition.

Subtraction is the converse of addition. Addition of two digits is performed by first counting the units of one digit and then continuing to count the units of the second digit. Subtraction is performed in a similar way except that the counting for the second digit is in the opposite direction.

Multiplication is a rapid form of addition. For instance,

$$\begin{array}{r} 5 \\ \times\ 6 \\ \hline 30 \end{array} \quad \text{is equivalent to} \quad \begin{array}{r} 6 \\ 6 \\ 6 \\ 6 \\ 6 \\ \hline 30 \end{array}$$

Since division is the converse of multiplication, division may be considered to be an advanced form of subtraction.

Even the process of integration used in calculus can be shown to be equivalent to a series of additions. Integration is a means for finding the area included by a curve. Mathematicians have developed formulas and rules for performing integration. But finding the area included by a curve can be done in a much more simple manner.

EXERCISES

I. Read fluently, paying special attention to stresses and pronunciation:

instead of building a costly experimental model, instead of using an actual airplane, formulas representing the effects, for a set of conditions, without any hardware, between the expansion of mercury and temperature, the basis for an analog computer, operations analogous to those of addition, the circuit of an electronic adder, results must be read off a scale, with which one can read a scale, eventually the point is reached.

II. Give all synonyms you know for:

работа, выполнять, например, помощь, происходить, точный, быстро, получать.

III. Find in the text equivalents for:

имеющийся в наличии, таким образом, в конечном счете, поэтому, чрезвычайно, независимо от, так как, при этих обстоятельствах.

IV. Memorize the plural of the following words:

phenomenon — phenomena; datum — data, maximum — maxima, nucleus — nuclei, radius — radii, axis — axes; basis — bases.

V. State what part of speech the words in italics belong to and translate the sentences:

1. The direction of the magnetic field at any *point* P is arbitrarily chosen as the direction in which a small magnetic needle *point* would *point* when placed at P without disturbing appreciably the existing conditions. 2. No *line* of force crosses another. 3. A freely suspended bar magnet *lines* itself up parallel with the lines of force existing between the north and south magnetic poles of the earth.

VI. Make up a plan of the text.

VII. Retell the text according to your plan.

VIII. Get ready to speak about digital and analog computers.

78. Memory

The electronic "memory" of a computer is a depot to store numbers and instructions. From this depot they are sent for processing to "the mathematical mill". The results obtained are returned to the "memory".

It may be said that the history of progress in high-speed computers coincides with the history of the improvement of their "memory". Quite recently the electron tube "memory was considered high-speed "memory". Next the ferrite-core "memory" was produced: The working speed of most up-to-date computers holds up to ten million bits. To increase the capacity and data production speed are the most important aims of contemporary computer construction. Tunnel diodes, cryogenic elements, thin magnetic films — these so called microminiaturization elements are used to construct the "memory".

Memory consists of three elements: storage, read and write circuits, and address selection. But any storage system requires these three elements. What distinguishes a memory from other types of storage?

To answer this question, let us look at different classes of storage. Storage may be classified according to size. There is bit storage, as exemplified by the flip-flop; there is word storage, as exemplified by the register and counter; and there is multiword storage which is exemplified by systems of bulk storage.

Storage may be classified according to whether it is external or internal. External storage exists outside the computer; it is not a fundamental part of the computer. Internal storage is an integral part of the machine; without it the computer cannot function.

Storage may be classified according to whether it is fixed or erasable. The contents of fixed storage cannot be changed. The contents of erasable storage can be changed — it can be written into.

To be considered memory, storage must be:

1. Bulk storage.
2. Internal.
3. Erasable.

Obviously one bit or one word cannot constitute memory; we need a device which can store many words. Internal storage implies that there is ready and quick communication between memory and the other functional units of the computer. Erasibility means 2-way access to words in memory, in as well as out.

To summarize, we may say that memory is accessible bulk storage which may be written into as well as read from.

External storage is used in the input and output systems. Fixed storage may be used in the control unit for storage of nonchangeable programs in special-purpose computers.

Modern science considers that many branches of knowledge depend to a great extent on the solution of the problem of human memory and on the levels of development of artificial computer memory.

EXERCISES

I. Find in the text synonyms for:

to receive, lately, velocity, field, man-made, to a great degree, purpose.

II. Find in the text English equivalents for:

совсем недавно, до некоторой степени, согласно, точно так же, как.

III. Memorize the following terms:

memory unit — блок памяти; storage — запоминающее устройство; to process — обрабатывать (данные); flip-flop — мультивибратор, триггер; erasable — стираемый (о записи); access — доступ к вычислительной машине; выборка, обращение.

IV. Put questions to the text and answer them.

V. Make up a plan of the text.

VI. Retell the text according to your plan.

79. Input-Output System

The input-output system consists of three parts:

1. Input and output units.
2. Auxiliary units.
3. Peripheral equipment.

The input and output units are internal functional parts of the computer. The auxiliaries are links between the computer and the outside world. The peripheral equipment is needed to make the operation of the computer more efficient and more meaningful.

The input unit consists of an input register plus associated input control circuits. The input unit receives signals from the control unit whenever a word or a group of words is to be entered into the machine. The input unit also makes incoming information more palatable than the rest of the computer.

The output unit consists of an input register plus associated output control circuits. The output unit receives signals from the control unit whenever a word or a group of words is to be removed from the machine. The output unit also modifies information so it can be more readily applied to the output auxiliaries.

Auxiliary devices either feed information into the computer or take information out of the computer. These auxiliary devices are of two general types: direct analog as well as digital, linked with external storage.

The direct-digital device communicates directly between man and machine. It may take the form of a keyboard for manually entering instruction or data words. It may be a printer which prints results of computations onto paper or a group of display lights on the control panel indicating the contents of internal registers.

The analog input auxiliary accepts analog information and converts it to digital form for entry into the input register. The analog output auxiliary receives digital information from the output register and converts it to analog form. The first device is called an analog-to-digital converter, the second being called a digital-to-analog converter.

The input auxiliary linked with digital storage reads information from external digital storage and feeds it into the input register. The digital auxiliary accepts information from the output register and writes it into external storage. Examples of such input and output auxiliaries are magnetic tape, punched paper tape, and punched-card readers and writers.

The peripheral equipment is concerned mainly with external digital storage. Recorders are used by operators to place information into external storage. An example is a device which writes words onto magnetic tape when keys of a keyboard are operated. Converters transform information stored in one form to information stored in another form. An example is the punched-card-to-magnetic-tape converter. Communication devices are used to send information to or from external storage. An example is a teletype.

The input and output units are integral portions of the digital computer. Under direction of the control unit they determine the shape, sequence, speed, and time of arrival of bits and words as they are transferred between the computer and auxiliary devices.

EXERCISES

I. Read fluently with due attention being paid to stresses and pronunciation:

under direction of control units, the time of arrival of bits, a word or a group of words, these auxiliary devices are of two kinds, a group of display lights, the contents of internal registers, the analogue output auxiliary, examples of input and output auxiliaries, to place information into external storage, communication devices are used to send information.

II. Form derivatives from the following words:

unit, compute, mean, operate, direct, accept, enter, store, record, place.

III. Give synonyms to the following words:

operate, modify, convert, link, mainly, shape, speed.

IV. Give antonyms to the following words:

input, internal, receive, enter, efficient.

V. Mind different meanings of the following words, illustrating these meanings in sentences:

rest, part, content, read, feed, record.

VI. Make up sentences using the following:

to be concerned with, either... or, readily, whenever, wherever, whoever.

VII. Find in the text a sentence expressing obligation and write 5 sentences illustrating other ways of expressing obligations.

VIII. Write out of the text all terms referring to computing technique.

IX. Put questions to the text and get ready to answer them.

X. Tell what you know about input — output systems.

80. Simple Hardware, Complicated Logic

The computer does only additions in a sequence determined by a logical control. This seems to imply that it is a simple machine. *In a sense it is*, since only a handful of different types of circuits are needed to build *the most awesome machine*[32] in existence. What then produces the complication? The complication is produced by the many interconnections among those few basic circuits.

A digital computer processes information. In that sense each part of it can be said to be communicating with or "speaking" to other parts of the machine. For this purpose the machine uses a "language". Whatever form this language may take, it must possess rules indicating how subjects are connected. These connectives are similar to connectives used in ordinary speech. Some of these grammatical connectives are "if", "all", "then", "also", "and", "or", "not", "only"... These connectives are the cement of the language. They indicate the relationships among the different elements of a sentence. Because they are so important for indicating relationships, they are the fundamental building blocks of logic. Now here is the important consideration. All the possible connectives may be reduced to only three basic ones — "and", "or", and "not". *Suffice it to say here*[33] that if a circuit could be developed for each of the three logical connections, we would have the necessary cement for the machine language. Then we would only need circuits to store the "positions" before and after being applied through the connective circuit. These connective and storage circuits are called logical elements.

Logical elements may take on many forms. Originally, relays were used for this purpose. Early in the development of electronic computers, relays were replaced almost entirely by vacuum tubes. But a new era began when the magnetic core, the transistor, and many other solid state devices were developed. These tiny components enable man to reduce the size of electronic computers to the point where they became feasible for use. In addition, the fact that only a handful of basic circuits are needed to construct a computer encouraged the development of plug-in packages. These plug-in packages simplified the maintenance problem tremendously.

EXERCISES

I. Read the following words with the proper stress and pronunciation:

compute, computer, computation; circuit, build; to imply, to apply, to supply, to simplify; communicate, communication; fundamental, experimental; suffice; case; basic; process; to process; subject, to subject.

II. Read fluently:

it does only additions in a sequence; the most awesome machine in existence; whatever form the machine may take; some of the grammatical connectives; among the different elements of a sentence; for indicating relationships; the fundamental building blocks of logic; suffice it to say here; before and after being applied through the connective circuits; almost entirely by vacuum tubes; where they became feasible; encouraged the development of plug-in packages.

III. Write out of the text all technical terms and memorize them.

IV. Find in the text synonyms for:

to define, as, various, to be referred to as, aim, shape, to show to link, like, usual, to use, initially, completely, very small, to decrease, dimension, possible.

V. Find in the text the sentences with:

1. Nominative Absolute Participial Construction; 2. Complex Subject with the Infinitive; 3. Complex Object with the Infinitive. **Analyse these sentences and translate them in a proper way.**

VI. Illustrate in sentences of your own the different meanings of *since* and *if*.

VII. Put questions to the text.

VIII. Be ready to speak on the topics given below:

1. The computer as a machine; 2. The basic circuits and the logical elements; 3. The work of a digital computer; 4. The language of the computer; 5. The connectives in a computer; 6. The forms of the logical elements.

81. Types of Instructions

Communication between man and machine may be accomplished automatically or manually. In the automatic method a complete program of instruction words and a list of required data words are prepared beforehand. This information is then loaded into the machine which then executes the instructions in proper sequence. The manual system of communication is accomplished by means of switches and controls on the front panel of the machine. Instruction words and data words may be fed individually into the machine; and instruction sequences may be modified. *The machine keeps the operator up to date on events within the computer*[34] by means of display lights which indicate the informational content of various registers and whether any arithmetic errors or component malfunction have occured.

In keeping with the general organization of the computer, several different types of instructions are used by man to communicate with the machine.

Most of the actual arithmetic work of the machine is performed by the arithmetic unit. We inform the machine to do these operations by means of arithmetic instructions which include: add, subtract, multiply, divide, square root, and shift right. Some of these instructions such as add and subtract refer to addresses in memory where operands are located. Other instructions, such as shift right, do not refer to memory. The first type of instruction requires an address portion. The second type does not require an address.

Before operations can be performed by the arithmetic unit, operands must be transferred to it. After the arithmetical unit has performed its work, results must be removed from it. Information must also be fed into and out of other registers in the computer. Man instructs the machine to perform these operations by means of transfer instructions. Transfer instructions may be of two types: read or write. In the first, a word is read out of memory into another register in the machine. In the second, a word is taken from another register and written into the memory. The memory location in both cases is given by the address portion of the instruction.

As long as the computer is performing simple arithmetic operations, transfer and arithmetic instructions are sufficient for communication. But the great advantage of the digital computer is that it can follow one sequence of instructions under one set of conditions and another sequence of instructions under another set of conditions. An instruction which asks the computer to do this is called a branch instruction. The branch instruction enables man to communicate with the computer's control unit to modify the sequencing of computer instructions.

EXERCISES

I. Read the following words with the proper stress and pronunciation:

communicate, formulate, indicate, elaborate, demonstrate; enable, require, transfer, control, arrange, perform; remove, compute; sufficient, efficient.

II. Memorize the following expressions and use them in sentences of your own:

in keeping with, as long as, most of, by means of, under these conditions, such as, up to date.

III. Make up words of the same stem:

to perform, to include, to add, to subtract, to multiply, to divide, to require, to modify, to move.

IV. Find in the text synonyms for:

some, various, the majority, to do, to demand, enough, to be named, to change.

V. Analyse the *ing*-forms in the following sentences:

1. The arithmetic unit consists of several registers for hold*ing* operands and arithmetic circuits work*ing* in conjunction with the register to perform different operations. 2. Other operations such as shift*ing* and tak*ing* the square root are performed on other operands.

3. By convert*ing* negative numbers to their complements, we can convert all subtraction problems into addition problems. 4. Algebraic addition refers to the summation of numbers, some of them be*ing* positive and some of them be*ing* negative. 5. While us*ing* the digitall computer, we can perform the computations in short time. 6. In keep*ing* with the general organization of the computer, several different types of instructions are used by man to communicate with the machine. 7. Shift*ing* and tak*ing* the square root require other operands, because of their be*ing* very complicated.

VI. Write out of the text all the technical terms and memorize them.

VII. Put questions to the text and answer them.

VIII. Be prepared to speak on types of instructions.

Part VI

ELECTRICAL ENGINEERING

82. Direct-Current Generators

The construction and operation of a d. c. generator are practically the same as those of alternators, the main differences being the commutator action, the method of field excitation and the necessity of always having the armature — the rotating member. This latter is required to permit the commutator to function.

The commutator consists of a number of wedge-shaped copper segments fitted together around one end of the armature. The segments are separated from each other by some insulating material. As a matter of fact thin sheets of mica are widely used, the two terminals of each armature coil are connected to adjacent commutator segments. Figure 22 shows an end view of an armature, with commutator and coil connections. For the sake of clarity, each armature winding is shown as a single loop.

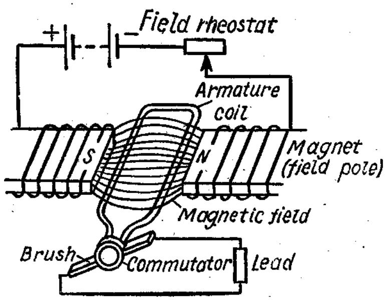

Fig. 22

In practice, the brushes make contact on the outer surface of the commutators. The commutator progressively switches the brushes from one end of an armature coil to the other end, *just as the coil starts to enter the opposite pole area*[35]. Thus although the direction of electron movement in the coil has reversed, the opposite end of the coil has been connected to the external circuit, direct current flowing out through the brush.

Direct-current generators are usually self-excited, some of the energy generated by the armature being used to energize the field windings. This is impossible in alternators, because the direction of the field flux must be constant; therefore direct current is required as a field excitation source.

Sufficient residual magnetism remains in the field poles to generate a small voltage when the armature starts to revolve. This current, fed into the field windings, is found to strengthen the magnetic field, which in turn causes more voltage to be developed in the armature. This process continues until the generator has been brought up to operating speed.

EXERCISES

I. Read the following words and their derivatives; observe that adding suffix *-or* does not shift the stress:

a) to 'operate, 'operator, ope'ration; to generate, generator, generation; to alternate, alternator, alternation; to commute, commutator, commutation; to insulate, insulator, insulation; to separate, separation; to ne'cessitate, ne'cessity, 'necessary, nece'ssarily.

II. Find in the text synonyms for the following words:

principal, to revolve, to call for, to allow, to be made up of, in effect, to apply, extensively, both, to join, to indicate, multiple, inner, in this way, though, motion, since, consequently.

III. Find in the text antonyms for the following words:

different, the former, to connect, conducting, internal, to weaken.

IV. Describe an end view of an armature, with commutator and coil connection as shown in Fig. 22.

V. Tell about the direct-current generator.

VI. Answer the following questions:

1. What is the difference between the construction and operation of a direct-current generator and those of alternators? 2. What segments does a commutator consist of? 3. How are the segments separated from each other? 4. What are the two terminals of each armature coil connected to? 5. How does the commutator operate? 6. How are direct-current generators usually excited? 7. Why is this impossible in alternators? 8. What does sufficient residual magnetism in the field poles generate? 9. In what way is more voltage developed in the armature? 10. How long does this process continue?

83. Alternating-Current Generators

The principles underlying magnetism, electromagnetism and electromagnetic induction are combined in the creation of electrical energy from mechanical energy (generators) and in the creation of mechanical energy from electrical energy (motors).

The generator consists of an outer frame or yoke to which are attached the pole pieces, always even in number, about which are erected the field windings. A cylinder of laminated iron called the armature, with longitudinal slots to contain the armature coils, is mounted on bearings so that it can rotate in the magnetic field set up by the pole pieces. One end of the armature terminates in a pair of slip rings. These are solid brass alloy rings fixed to the armature, the respective armature coil terminals being connected to each ring. Carbon brushes rest upon the slip rings in order to provide the current with a path to an external circuit.

We know the field poles to be wound with wire in such a direction that the magnetic field strength is increased when direct current from an outside source is supplied to the field windings. A variable resistance, referred to as a field rheostat, is placed in this circuit to permit control of the field strength.

Armature. The armature of a generator is rotated in the magnetic field between the field poles by some mechanical device. This may be a steam engine, a gasoline engine, an electric motor or some other agency. The rotation of the armature upon which the armature coils are wound causes the coils to cut the magnetic lines of force between the field poles. Inasmuch as the direction of electron flow is determined by the direction of conductor movement in relation to magnetic flux, current will flow in opposite directions in the opposite coil sides. This occurs because during one half revolution one side is moving up through the field, the other side moving down through it. In the next half revolution, however, the first side moves down through the field, while the second moves up. It is apparent that alternating current is generated and fed through the slip rings and brushes to the external circuit.

Frequency. The number of times per second the current reverses itself is known to be its frequency and is determined by the speed of the armature and the number of field poles. Thus a generator with two sets of field poles, whose armature turns 1 complete revolution per second (rps), would have a frequency of 2 cycles. With one set of field poles, an armature must turn 2 rps to attain the same frequency.

EXERCISES

I. Read the following words;

brass, class, pass, path; out, about, outer, outside, found, wound, amount; pair, bearing; generator, operator, alternator, to laminate, to terminate, terminal, armature, variable, gasoline, agency, frequency; to attain, alloy, to occur, cont'rol, [ou], apparent; longitudinal.

II. Find in the text synonyms for the following words:

to supply, to allow, to take place, to define,as, velocity, full, to reach, instrument, evident.

III. Find in the text antonyms for:

inside, up, internal, odd, to decrease.

IV. Choose one of the topics below and prepare to talk on it:

1. The frame or yoke of the generator. 2. The armature of the generator. 3. Brushes and slip rings. 4. The field poles. 5. The rotation of the armature. 6. Frequency.

V. Put questions to the text and answer them.

VI. Compare the d. c. and a. c. generators.

84. Transformers

Unlike the generator, a transformer cannot be used to convert mechanical energy into electrical energy, it being able to transform electrical energy from one circuit at the same or some other voltage.

Essentially, a transformer consists of two coils, not electrically connected to each other, but wound over a common core. The core may also be of open type, or it may be merely a tube of some insulating material, the latter being referred to as an air core.

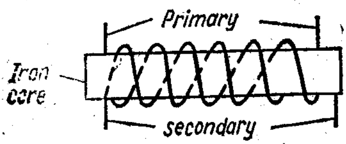

Fig. 23

If a varying voltage be applied to the primary coil, the electromagnetic field set up around the coil will rise and fall in accordance with the e. m. f. variations applied. This moving field cuts the turns in the secondary coil and induces an e. m. f. therein. The value of this induced e. m. f. depends upon the strength of the applied e. m. f. and the ratio of secondary turns to primary turns. Should there be twice as many turns in the secondary as in the primary, the voltage in the secondary would be twice that applied to the primary. If there were half as many turns in the secondary, the voltage would be half that applied to the primary. This voltage step up or step down in proportion to turn ratio will hold good for all combinations. Where the voltage is raised, however, amperage is lost in the same proportions, and vice versa. Therefore, the power in watts supplied to the transformer is the same as that drawn from it, assuming the transformer to be 100 per cent efficient. The copper losses, or ohmic resistance of the windings, and the core losses due to the induction of eddy currents in the core material, as well as hysteresis or molecular friction caused by changing polarity of the current applied, all combine to reduce modern transformer efficiency to about 90 per cent.

Transformers are classed according to the use they are designed for. Where it is desired to step up a low-voltage a. c. supply to a value useful for radio receivers and transmitters, a power transformer is used. The windings are sufficiently heavy to carry the current without undue heating, and the secondary may consist of two or more separate windings to provide various voltages from one input source.

As the iron core increases, the inductive reactance of the transformer increases, and inasmuch as this type of reactance also increases with the frequency of the applied alternating current, there is a limit to the frequencies that can be efficiently used in transformers with metallic cores. Where very high-frequency alternating current is used such as in the r-f circuits of receivers and transmitters, air core transformers must be used to eliminate prohibitive core losses.

EXERCISES

I. Read the following words:

core, source, vary, merely, circuit, winding, design, frequency, primary, secondary, molecular, essentially, sufficiently, efficiency, eliminate, prohibitive, hysteresis.

II. Find in the text the Conditional sentences, analyse and translate them.

III. Find in the text English equivalents for:

и наоборот; точно так же, как; по сути; в соответствии с; иметь силу (быть справедливым), следовательно, поскольку, согласно.

IV. Translate and memorize the following terms:

core, secondary turns, primary turns, step up, step down, winding, eddy currents, inductive, reactance.

V. Translate the following sentences, paying attention to the different meanings of the words and word groups in italics:

1. In a generator the pole pieces are always *even* in number. *Even* the slightest changes in frequency can be detected by the new device. 2. Carbon brushes *rest* upon the slip rings fixed to the armature. The machine is *at rest*. The efficiency of the machine is 85%, *the rest* of the power being lost in the resistance to friction. 3. A gene-

rator with two sets of field poles, whose armature *turns* 1 complete revolution per second (rps) would have a frequency of 2 cycles. 4. The strength of an electromagnet with a given core is known to be proportional to the number of ampere *turns*. 5. Steam may be passed into an engine to produce mechanical energy. This *in its turn* may drive a dynamo to produce electrical energy. 6. We use soft iron not only *because of* its high permeability but because its low retentivity allows very little residual magnetism when the current is turned off. 7. An electrochemical cell which delivers electrical energy *by virtue of* the difference of potential between its electrode is known as a galvanic cell. 8. Electrolytes conduct the current *owing to* the presence of ions both positive and negative. 9. The molecules are held in position *due to* the rigidity of the crystal. 10. Heating causes the magnet to be demagnetized *on account of* the fact that it permits the molecules to adjust themselves to equilibrium position.

VI. Answer the following questions:

1. What is a generator used for? 2. What is a transformer used for? 3. What does a transformer consist of? 4. What kinds of cores do you know? 5. How does the electromagnetic field around the primary coil change if a varying voltage is applied to it? 6. What does the value of the induced e. m. f. depend upon? 7. How are transformers classed? 8. When does the inductive reactance of the transformer increase? 9. Where must air core transformers be used?

VII. Describe the structure of a transformer as shown in Fig. 23.

85. Single-Phase Motors

Types of Single-Phase Motors. Great numbers of motors of comparatively small horsepower rating are designed to operate when connected to a single-phase source. Most of them, built in fractional-horsepower sizes, are technically termed small motors, a small motor being defined as "a motor built in a frame smaller than that having a continuous rating of hp, open type, at 1,700 to 1,800 rpm". Single-phase motors are known to perform a great variety of useful services in the home, the office, the factory, in business establishments, on the farm, and many other places where electricity is available. The requirements of the numerous applications differing so widely, the motor-manufacturing industry has developed several types of such machines, each type having operating characteristics that meet definite demands. For example, one operates satisfactorily on direct current or any frequency up to 60 cycles; another rotates at absolutely constant speed, regardless of the load; another develops considerable starting torque; and still another, although not capable of developing much starting torque, is nevertheless extremely cheap to make and very rugged.

The type of motor that performs with about equal satisfaction on direct current or alternating current up to 60 cycles is considered to be the familiar d-c series motor. It is common practice that such motors are generally constructed in small sizes, operate at high speed, and include special design features, so that commutation and armature-reactance difficulties are minimized. Since they may be connected to any of the commonly available sources of supply, they are appropriately referred to as **universal** motors.

The induction principle is applied to several types of single-phase motor. This principle involves the production of a revolving magnetic field, several methods having been developed for doing this in single-phase motors. One of these methods is employed in the shaded-pole motor, an extremely popular small motor used in low-starting-torque applications. The so-called **reluctance-start** motor is a second type of machine, made in rather limited numbers in small sizes, that utilizes still another method to create the effect of rotating poles.

The **split-phase** type is considered perhaps to be the most widely used of all motors connected to single-phase sources of supply. It is manufactured in a great many sizes and styles, offering the user a choice of a number of desirable operating characteristics. There are, for example, (1) standard split-phase motors, (2) motors that employ a capacitor during the starting period only, and (3) motors that make use of one or more capacitors for starting and running duty. Much excellent design and development work has been done in recent years on this type of machine because of motor manufactures having felt that the great volume of business justifies their constant improvement.

Repulsion, repulsion-induction, and repulsion-start motors are other types of single-phase machines that were widely applied until recent years. They have been largely replaced by split-phase motors of the capacitor type because the latter can be designed to perform as well as the repulsion types, offering in addition such advantages as lower cost and trouble-free service.

Synchronous motors, as the name implies, operate at synchronous speed for all values of load. There are several constructions of such machines, although they are usually manufactured in very small ratings. Depending upon the way in which they are made or their principle of operation, they have special names such as **reluctance** motors, **subsynchronous-reluctance** motors, and **hysteresis** motors.

EXERCISES

I. Find in the text synonyms for the following words:

to link, dimension, to be called, to determine, to do, demand, the use, for instance, stable, irrespective of, almost, velocity, usually, to make use of, may be, some.

II. Form nouns from the following verbs and translate them:

to vary, to establish, to apply, to satisfy, to choose, to improve, to offer, to add, to characterize, to differ, to use, to desire.

III. Form adjectives from:

number, to compare, to define, to consider, to desire, to involve, value.

IV. Find in the text English equivalents for:

имеется в наличии, независимо от, общепринято.

V. Memorize the following terms:

rating, starting torque, reluctance motor, shaded-pole motor, split-phase motor, repulsion-start motor, trouble-free, load.

VI. Translate the following sentences:

1. In the figure are shown the conclusions they arrived at after having studied the problem of current and voltage in phase. 2. The thing one must have in view while dealing with resistance is that it is impossible to construct a circuit "with resistance only". 3. The curve we referred to represents the angle of a lag or lead of the current under consideration. 4. It is very important to know the time the current passes the midway between the given points, because of its being of great importance for the test in question. 5. Not only will the oscillogram show the number of times a second the current alternates, but it will also show how closely the current approaches a sine wave in form.

VII. Be ready to answer the following questions:

1. What kinds of motors are technically referred to as "small motors"? 2. Under what conditions are they designed to operate? 3. Where can single-phase motors be made use of? 4. What types of such machines have been developed by the motor-manufacturing industry? 5. What type of motor works equally well both on direct and alternating current up to 60 cycles? 6. What characteristic features of such motors do you know? 7. What type of motors connected to a single-phase source of supply is the most widely used one?

VIII. Choose one of the topics below and prepare to talk on it:

1. The split-phase type. 2. The repulsion-induction and repulsion-start motors. 3. Synchronouns motors.

IX. Write a summary of the text.

86. Polyphase Induction Motors

Induction-Motor Principle. In the electric motor, conversion of electrical power (or energy) to mechanical power (or energy) is known to take place in the rotating part of the machine. In the d-c motor and in one type of a-c motors, the electrical power is conducted directly to the rotor through brushes and a commutator; in this respect it is possible to designate such a machine as a conduction motor. In the most common type of a-c motors electrical power is not conducted to the rotor directly; the rotor receives its power inductively in exactly the same way as the secondary of a transformer receives its power. It is for this reason that motors of this type are known as induction motors. In fact, it will become apparent, as the analysis proceeds, that it will be extremely useful to think of an induction motor as a sort of rotating transformer, i. e., one in which a stationary winding is connected to the a-c source, while the other winding, mounted on a structure that is free to turn, receives its power by transformer action while it rotates.

The principle of the induction motor was first discovered in 1824, when the following interesting phenomenon was shown: if a non-magnetic disk and a compass are pivoted with their axes parallel, so that one or both of the compass poles are located near the edge of the disk, the compass will rotate if the disk is made to spin, or the disk will rotate if the compass is made to spin. The direction of the induced rotation in one element is always the same as that imparted to the other. Such an experiment can be readily performed if a simple copper or aluminum disk and a rather large compass are both mounted on the same vertical stem so that each may be rotated in its own bearing independently of the other. There is no more effective way to demonstrate the principle of the induction motor, of which there are several types. If the disk were rotated, the compass would follow at a speed always less than that of the disk; if the compass were rotated, the disk would follow the former at a lower speed.

It should be clearly understood that motor action (rotation of the disk) is developed by induction. The current in the rotor (disk) is the result of electromagnetic induction, which, it will be remembered, requires that there be relative motion between flux and conductors. Thus, if the mechanical load on the rotor increases, the rotor slows down; this slowing down means greater relative motion between flux and rotor, a greater voltage and current, *and hence more power to take care of the added load*[36]. In other words, the power developed by the rotor automatically adjusts itself to the power required to drive the load.

In the actual motor, the rotor is obviously not a disk, but a well designed structure consisting of a laminated core containing a winding; nor is the main field a single concentrated pole moved by hand, but an even number of poles formed by a distributed winding in a slotted stator. The stator poles are formed by the interaction of the fields of two or three phases, their result being the creation of an effect that is equivalent to a set of revolving poles.

EXERCISES

I. Give all the synonyms you know for the following words:

to convert, to take place, common, exactly, in the same way, to receive, in fact, apparent, to connect, readily, to perform, speed, to require, to slow down, motion, main, to revolve, several.

II. Form nouns from the following words and translate them:

to convert, to receive, to reason, to link, to demand, to increase, to move, to supply, to depend, to transform, to perform, inductive, various, free.

III. Form adverbs from the following adjectives and translate them:

ready, large, high, late, short, recent, direct.

IV. Form adjectives from the following words and translate them:

power, electricity, to relate, to add, station, reason, to depend, to compare, care, value, to adjust, to move, to create.

V. Give the different meanings of the following words and illustrate their use in sentences:

as, to make, even, that.

VI. Describe the induction-motor principle.

VII. Describe the induction-motor action.

VIII. Translate the following sentences:

В электрическом моторе происходит превращение электрической энергии в механическую. Индукционный мотор можно рассматривать как вращающийся трансформатор. Ток в роторе является результатом электромагнитной индукции. Ротор состоит из пластинчатого сердечника, содержащего обмотку. Главное его поле имеет четное число полюсов. В статоре полюса образуются взаимодействием полей двух или трех фаз.

87. Electrical Measuring Instruments

I

General Electrical Principles. To measure the magnitude of any phenomenon calls for the use of the effects produced by it. For the measurement of a mass, for example, we determine its weight; or we might utilize the force required to give it a certain acceleration. Again, for the measurement of temperature we use the expansion of solids, liquids, or gases, the change in electrical resistance of a wire, or the thermo-electromotive force produced at the junction of two conductors, etc. For the everyday measurement such indicating instruments are most convenient, in which the amount of the quantity to be measured is directly shown by the position of a pointer on a graduated scale or dial.

For the production of such instruments, some effect is employed which enables the phenomenon to be measured to produce a mechanical force tending to move the pointer along its scale; this is resisted by a controlling force which tends to move the index in the opposite direction, towards some zero position. The actual displacement of the index, or deflection, is the resultant of these two forces, and is greater the greater the magnitude of the deflecting force or of the phenomenon to be measured.

As a matter of fact, one single principle is known to underlie all electro-magnetic instruments, viz. that the current-carrying circuit tends to enclose as large a magnetic field as possible. In the moving needle galvanometers the magnetic needle turns so that more of its lines of force pass through the coil, while in the moving coil instrument the coil sets itself so as to enclose as much of the field of the magnet as possible. In the soft iron instruments the iron moves so as to increase the magnetic flux produced by the coil, and in the dynamometer the moving coil turns so that its magnetic effect increases that of the fixed coil. Should the conducting circuit be made entirely of flexible material in a uniform field, it would become circular in order to enclose the maximum possible area, while, if the current flowed in a liquid conductor — such, for instance, as mercury — it would actually try to reduce its section so as to shorten the path of the lines of force around it. To such an extent is this the case that it is difficult to pass a large current along such a conductor owing to the tendency of the mercury to contract and break the circuit.

EXERCISES

I. Read the following words, paying attention to the pronunciation of the vowels in italics:

l*i*ght, r*i*ght, m*i*ght; *ei*ght, w*ei*ght; m*o*st, p*o*st, b*o*th, *o*nly, *o*ld, c*o*ld; gr*ea*t, br*ea*k; ch*a*nge, arr*a*nge; s*a*mple, ex*a*mple, br*a*nch, adv*a*ntage; t*u*rn, th*er*mo, det*er*mine, c*er*tain, m*er*cury; c*ir*cuit, c*ir*cular; z*e*ro, mat*e*rial, *a*rea.

II. Write derivatives from the following words and translate them:

to measure, to determine, to expand, to resist, to tend, to increase, to contract.

III. Underline the suffixes and prefixes and state the part of speech the following words belong to:

enable, displacement, underline, enclosure, misprint, disconnect, interconnection, counteract, overload, underload, preheater.

IV. Give synonyms for the following words and word combinations:

to require, magnitude, to determine, certain, to indicate, quantity, entirely, while, to reduce, for example, to such an extent, i. e., viz., to utilize, owing to.

V. Be ready to answer the following questions:

1. What must one determine for the measurements of the mass? 2. What is used for measuring temperature? 3. What indicating instruments are most convenient for every-day measurement? 4. What effect is employed for the production of such instruments? 5. What single principle is known to underlie all electromagnetic instruments? 6. How does the magnetic needle turn in the moving needle instruments? 7. How does it turn in the moving coil instruments? 8. How does the iron move in the soft-iron instruments?

VI. Retell the text.

88. Electrical Measuring Instruments

II

Electrical measuring instruments depend for their action on[37] one of the many physical effects of an electric current or potential, and they are usually classified according to which of these effects is used. In addition, instruments are grouped as to whether they are 1) Indicating, 2) Recording or 3) Integrating.

Indicating instruments are those which indicate the magnitude of a quantity, and generally make use of a dial and a pointer. Ordinary ammeters, voltmeters, and wattmeters *fall into this class*[38].

Recording instruments give a continuous record of the quantity being measured, as for instance by an ink on paper record or graph, extending over a selected period of time.

Integrating instruments give the total amount of energy or quantity of electricity over a period of time. The summation they give is the product of time and an electrical quantity, ampere-hour and watt-hour meters being examples. The summation values are generally given by a register, consisting of a set of dials and pointers.

In every indicating instrument there are essentially two systems, one being fixed and the other being capable of relative movement. It is desirable that the movement of this latter system should bear some simple relation to the quantity being measured, that its movement should follow the changes in the quantity in such a way that readings can be obtained in a minimum of time, and that the expenditure of energy within the instrument proper shall be as small as possible.

To fulfil these conditions it is therefore necessary that the action of the instrument should depend upon a simple law, that there should be critical damping to the motion, and that such quantities as mechanical friction, heating, and magnetic hysteresis should be reduced to the lowest possible values. The reduction of mechanical friction is entirely a matter of correct design, and is dependent upon the method of supporting the movement. In general three methods are employed in commercial instruments, viz.: (a) pivoting, (b) knife-edge suspension, (c) pillar or thread suspension.

EXERCISES

I. Find in the text equivalents for the following:

in this manner, according to, in addition to, to make use of, consequently.

II. Make up sentences illustrating the use of the above expressions.

III. Translate the following words and groups of words:

to desire, desirable, as desirable; relation, in relation with; available, to be available; entire, entirely; account, on the account of, to take account of.

IV. Find in the text synonyms for:

generally, to show, amount, example, to take advantage of, to be composed of, to get, to choose, motion, fully, to carry out, to decrease, hence, namely.

V. Mind the following pairs of words:

to read — reading, to point — pointer, to record — recorder, to set — a set, to produce — product.

VI. Find in the text sentences with the Subjunctive Mood and analyse them.

VII. Put questions to the text and answer them.

VIII. Give a general description of different kinds of electrical instruments and compare them.

89. Ammeters and Voltmeters

The action of almost all the types of measuring instruments is such that an electric current as distinct from an electric potential, is primarily responsible for the ultimate mechanical force required to produce movements of the instrument pointer. This has an exceedingly important influence on the practical forms of ammeters and voltmeters. By this is meant, that all, except the electrostatic type of instrument, are fundamentally current-measuring devices. They are fundamentally ammeters. Consequently, most voltmeters are merely ammeters so designed as to measure small values of current directly proportional to the voltages to be measured. It is only natural, therefore, that voltmeters and ammeters should be classed together.

A m m e t e r s, which are connected in series in the circuit carrying the current to be measured, are of low electrical resistance, this being essential in order that they cause only a small drop of voltage in the circuit being tested, and accordingly absorb a minimum power from it.

V o l t m e t e r s are connected across, that is, in parallel with, the circuit points where the voltage is to be measured, and are of high resistance, in this case sufficiently high so that the current flowing in the voltmeter, and the power absorbed from the circuit, are as small as possible.

The principle upon which both of these devices operate is essentially the same as that of the electric motor, differing from the motor, however, in the delicateness of their construction and the restrained motion of the rotating armature.

A coil of fine copper wire is so mounted between the two poles of a permanent magnet that its rotation is restrained by a hairspring. The farther the coil is turned from its equilibrium or zero position, the greater is the restoring force. To this coil is fastened a long pointer at the end of which is a fixed scale reading amperes if it is an ammeter or volts if it is a voltmeter. Upon increasing the current through the moving coil of an ammeter or voltmeter the resultant magnetic field between coil and magnet is distorted more and more. The resulting increase in force therefore turns the coil through a greater and greater angle, reaching a point where it is just balanced by the restoring force of the hairspring.

Whenever an ammeter or voltmeter is connected to a circuit to measure electric current or potential difference, the ammeter must be connected in series and the voltmeter in parallel. As illustrated in Figure 24 the ammeter is so connected that all of the electric current passes through it. To prevent a change in the electric current when making such an insertion, all ammeters must have a low resistance.

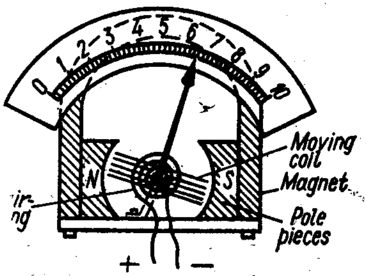

Fig. 24

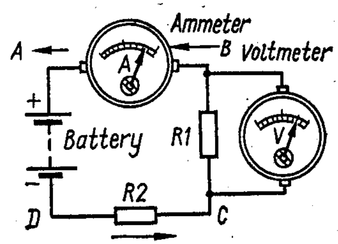

Fig. 25

Hence, most ammeters have a low resistance wire, called a shunt, connected across the armature coil.

A voltmeter, on the other hand, is connected across that part of the circuit for which a measurement of the potential difference is required. The potential difference between the ends of the resistance R_1 being wanted, the voltmeter is connected as shown. Should the potential difference across R_2 be desired, the voltmeter connections would be made at C and D, whereas if the potential difference maintained by the battery were desired, they would be made at A and D. In order that the connection of a voltmeter to a circuit does not change the electric current in the circuit, the voltmeter must have a high resistance. If the armature coil does not have a large resistance of its own, additional resistance is added in series.

Very delicate ammeters are often used for measuring very small currents too. A meter whose scale is calibrated to read thousandths of an ampere is called a milliammeter, one whose scale is calibrated in millionths of an ampere being known as a microammeter or galvanometer.

EXERCISES

I. Read the following words:

high, design, farther, fasten, series; influence, illustrate, calibrate, delicate, ultimate, consequently, primarily; diameter, microammeter, galvanometer, equilibrium, fundamentally, sufficiently.

II. Find in the text the Infinitives and analyse their function.

III. Give Russian equivalents for:

by this is meant, consequently, whenever, hence, on the other hand.

IV. Describe the principles of the operation of:

a) voltmeters, b) ammeters.

V. Describe the Figures of the text.

VI. Prepare to put questions to the text and to answer them.

VII. Write a summary of the text.

90. Wattmeters

Instruments designed to measure the amount of power passing in a circuit are known as wattmeters.

In the case of D. C. circuits the power taken is the product of the voltage and the current flowing. Ammeter readings become almost a sufficient indication of the power taken and the installation of wattmeters an unnecessary expense.

Due to a factor which must be taken into account, namely, the power factor or phase relationship between the voltage and current, the power taken by even the simplest two-wire A. C. circuit is not so easily estimated. In some A. C. circuits, then, the installation of a wattmeter is necessary if the power is to be measured.

Common forms of wattmeter, as installed on switchboards or as portable instruments, are of the direct-indicating type with pivoted moving elements. Other forms used as standard for calibration and classed as laboratory equipment have a torsion head suspension and are "indirect" reading.

Since their modes of operation are basically the same as certain types of ammeter and voltmeter, it is only to be expected that their individual mechanical and electrical component parts are identical with or bear a close resemblance to those already considered. They will, in general, be restricted by the same errors and disadvantages, and will gain by the same advantages.

EXERCISES

I. Read fluently:

the amount of power, the product of the voltage and current, a sufficient indication of the power taken, must be taken into account, by even the simplest circuit, installed on switch-boards, the installation of wattmeter, direct-indicating type, their modes of operation.

II. Add suffixes and prefixes to the following words and translate the words into Russian:

advantage, sufficient, to estimate, to install, power, use, to expend.

III. Make nouns from the following verbs and translate them:

to produce, to relate, to estimate, to suspend, to resemble, to expend.

IV. Give the different meanings of:

reading, product.

V. Memorize the following expressions and compose sentences with them:

to take into account, to bear a resemblance to, due to.

VI. Answer the following questions:

1. What is the power taken in a D. C. circuit? 2. What is the indication of the power taken? 3. Is it easily estimated? 4. What types of wattmeters are used? 5. Are their modes of operation different from those of ammeters and voltmeters?

VII. Retell the text.

91. Resistance Measurement

The choice of a suitable method of measuring resistance will depend on several different factors, some of the more important being as follows. The range of resistance to be measured, that is, whether low (less than 1 ohm), medium, or high (100,000 ohms and above). The required accuracy of the measurement, greater, say, than 1 per cent, or not, and the ease with which it can be made. Whether the measurements are to be made with the item tested under its normal working conditions or away from these. This latter point can be rather important when we consider that the resistance of conducting materials increases with temperature, and hence with the amount of current flowing through them, whereas the resistance of insulating materials decreases with temperature rise, as well as with the absorption of moisture, where these are hygroscopic.

In any particular case the choice of method will be limited to one or two, depending on the equipment available. The various methods can be divided into two classes, laboratory, and workshop methods. This division again depends on the accuracy with which the measurement is to be made, as the same basic principles are used in many cases. "Laboratory test measurements" generally infers that the greatest precision is obtained with a given method. On the other hand "workshop measurements" infers modifications to a method to give greater ease of manipulation, with direct reading if possible, and less emphasis on the accuracy obtained, provided that it is within useful limits.

EXERCISES

I. Read fluently:

a suitable method, the required accuracy, normal working conditions, the method can be divided, can be rather important, increases with temperature, the amount of current flowing, the resistance of insulating materials, the absorption of moisture, with a given method, with direct reading.

II. Find in the text sentences with:

1. Nominative Absolute Construction. 2. Participles used Attributively.

III. Find in the text English equivalents for:

отсюда, в то время как, в особом случае, с другой стороны, при условии, что, т. е.

IV. Make a plan of the text.

V. Retell the text according to the plan.

VI. Translate into English:

Практической единицей сопротивления является ом. Сопротивление обычных проводящих материалов, как правило, не на много больше 1000 ом. Сопротивление изоляционных материалов обычно составляет миллионы омов. Удобной практической единицей является Мегом (1.0 megohms = 1.0 million ohms = 10^6 ohms). Так как электрическое оборудование включает как проводники, так и изоляторы, то работа оборудования будет зависеть от каждого из его составляющих (component) материалов.

92. Low and Medium Resistance Measurements

The D. C. potentiometer can be used for measuring resistances of very low value, such as instrument shunts. This is really a laboratory or test room method, and is based on the comparison of one resistance against another by an indirect method. It employs the potentiometer for the accurate measurement of the drop in voltage across both the shunt under test and another shunt of known resistance, when both are carrying the same current.

Medium Resistance Measurement. This is perhaps the most frequently used workshop method of measuring resistance, using an indicating voltmeter and ammeter. The resistance being measured can be left connected in its normal working circuit if desired, with the ammeter and voltmeter added.

If the current I flowing through the resistance is measured in amperes when a voltage V is applied across the resistance, then, by Ohm's law, the resistance R is given by:

$$R = \frac{V}{I} \text{ ohms}$$

The required range of voltmeter and ammeter to be used and the voltage of the supply necessary, if this be different from the resistor's normal working circuit, will depend on the size and rating of the resistance being tested. A high-value resistance will tend to require a high-voltage source, a high-range voltmeter, and a low-current range ammeter, whereas a low-value resistance will require in most cases a low-voltage, high-current source, a low-range voltmeter and high-range ammeter. The exact requirements will, of course, depend also on the rating of the resistance, as well as the instruments available.

EXERCISES

I. Find in the text synonyms for:

to demand, dimension, accurate, while, quantity, probably, to wish.

II. Give Russian equivalents for:

испытываемый, по желанию, точно так же, как; имеющийся в наличии.

III. Find in the text:

1) the Present Participles Active and Passive, the Past Participles and state their functions; 2) the Infinitive used Attributively.

IV. Translate into Russian and memorize such technical terms:

high-value resistance, a high-range voltmeter, high-current source, high-range ammeter, a low-range voltmeter, low-current range ammeter.

V. Put questions to the text.

VI. Translate the following questions and answer them:

1. Когда используется потенциометр постоянного тока? 2. На чем основан лабораторный метод измерения сопротивления? 3. Для какой цели используется потенциометр? 4. Как можно определить сопротивление? 5. От чего зависят изменения сопротивления?

VII. Retell the text.

Part VII

TEXTS FOR CLASS WORK

1. Electrons and Electric Charges

An atom of ordinary hydrogen is composed of one positively charged proton as a nucleus and one negatively charged electron. The proton is about 1,840 times more massive than the electron. Heavier atoms are believed to be built up of protons, neutrons, and electrons. When a body is negatively charged, it has excess electrons; if positively charged, there is a deficiency of electrons.

In metallic conductors many of the electrons are free to travel about among the atoms like molecules of a gas.

When electric charges are "static" they do not progress in any definite direction. Excess electrostatic charges reside on the outer surface of a conductor, their density being greatest in regions of greatest curvature.

In charging a body A negatively by induction, a body B, positively charged, is brought near it. When A is grounded, electrons travel from the earth to it, and the connection to the earth is broken. Meanwhile the charge of B does not change.

EXERCISES

I. Read and translate the text without a dictionary.

II. Answer the following questions:

1. What is an atom of ordinary hydrogen composed of? 2. What are the heaviest atoms built up of? 3. When has a body an excess or a deficiency of electrons? 4. When do electric charges not progress in any definite direction? 5. Where do excessive electrostatic charges reside and where is their density the greatest?

2. Conductors and Non-Conductors

Substances that offer great resistance to the passage of charges are called insulators. There is no sharp boundary between conductors and insulators. Metals and carbon are good conductors. Pure water, amber, rubber, and glass are insulators; impure water containing dissolved acids, salts, or bases is intermediate in conductivity. Some materials, called semiconductors, conduct well only under certain conditions, as when light falls on them or when their temperature is raised.

EXERCISES

I. Make a written translation of the text.

II. Make a retranslation of the text.

3. Electrical Fields

There are two fields in electricity: the electrostatic and the magnetic. These are found at right angles to each other around the electron. The electrostatic field, although present between the terminals of an e. m. f. source, is seldom used to do work in electrical circuits. A common location of this type of field is found between the plates of a charged condenser.

A current in a coil causes a magnetic field around the conductor. If the current is alternating, the field will build and collapse with the current alternations. When another coil is brought into the field of the first coil, because magnetic lines of force are being cut by a conductor periodically, an e. m. f. is developed in the second coil. The intensity of a field varies inversely as the square of the distance travelled. If that distance is doubled, the intensity is one-fourth the original. The extent or strength of a field depends upon the magnitude of the current.

EXERCISES

I. Read and translate the text without a dictionary.

II. Put 5 questions to the text and answer these questions.

III. Retell the text.

4. Continuous, Direct, Pulsating, Alternating and Oscillatory Currents

A "continuous" electric current is defined as a current which is always in the same direction but may vary or pulsate in value. The term "direct current" is ordinarily used to designate either a continuous current or a current which varies or pulsates only by an inappreciable amount, such as the current from a battery or direct current generator. A "pulsating" current is a direct current which pulsates by an appreciable amount, such as the current from a rectifier. An "alternating" current is a current which reverses in direction, being first positive and then negative, but alternates between constant maximum positive and negative values. An "oscillatory" current is a current which reverses in direction, oscillating between positive and negative values which either decrease or increase with time.

EXERCISES

I. **Read the text.**

II. **Give definitions of the different kinds of current.**

5. Ohm's Law and Resistance

The free electrons which contribute to the electric current have a low drift velocity in the negative direction of the field within the conductor. In moving through the metal in a common general direction they enter into frequent collisions with the molecules of the metal, and as a consequence they are continually retarded in their forward motion and are not able to attain a velocity greater than a certain terminal velocity **u**, which depends on the value of the field and the nature of the substance. The collisions which tend to reduce the drift velocity of the electrons act as a retarding force. When a current is flowing, this retarding force must be exactly equal to the accelerating force of the field.

EXERCISES

I. **Read and translate the text.**

II. **Retell the text.**

6. Magnets and Magnetic Substances

A magnet may be defined as any body which possesses the property of attracting pieces of iron or steel and which when freely suspended takes up a definite position with respect to the geographical meridian. A magnetic substance is any body which acquires this property when it is placed near a magnet or near a conductor carrying an electric current. A body which is given this property is said to be "magnetized". A magnetic needle is a magnetized needle of iron or steel; the north seeking end of such a needle is referred to as its north pole and the south seeking end as its south pole. A needle is said to be freely suspended when there is no controlling force exerted upon it through its suspension tending to make it take up any definite position. Such a needle being freely suspended near a magnet or a conductor carrying an electric current, a force is bound to be exerted upon it which causes it to take up a definite direction. The needle is said to "point" in the direction of a line drawn through it from its south to its north pole.

EXERCISES

I. Read and translate the text without a dictionary.

II. Speak about magnetic substances.

7. The Magnetic Field

Magnets exert a force on some metals. In order to draw some material to itself and hold it in opposition to the law of gravity, the magnetic field must exert a force. There is an invisible magnetic field between the poles of the magnet. This field is considered to be composed of lines of force, and, inasmuch as force has direction, these lines are thought to be leaving the north pole or end of the magnet and entering the south pole.

Note that the density of the lines is greatest at the poles, and that no line of force crosses another.

This latter phenomenon is the reason why a freely suspended bar magnet will line itself up parallel with the lines of force existing between the north and south magnetic poles of the earth.

In the mariner's compass, the end of the magnet that points toward the earth's north geographic pole is called the north pole, the other end being the south pole. If the bar magnet is bent into the shape of a U, it forms the familiar horseshoe magnet. Note that the path of magnetic flow is shortened and intensified.

EXERCISES

I. Read the following words of the text:

exert, invisible, inasmuch, law, itself, gravity, latter, phenomenon, earth, familiar, intensify.

II. Read and translate the text.

III. Retell the text, answering the following questions:

1. What influence do magnets exert on some metals? 2. What field is there between the poles of the magnet? 3. What does this field consist of? 4. Why does a freely suspended bar magnet line itself up parallel with the lines of force existing between the north and south magnetic poles of the earth? 5. What kinds of magnets do you know? 6. What is horseshoe magnet?

8. Phase

The current in a circuit may have its maximum and zero values at the same time as those of the e. m. f. wave, or these values may occur earlier or later than those of the latter. When the corresponding values of the current and e. m. f. occur at the same time they are said to be in phase. If the current values occur before the corresponding values of the voltage wave, the current is said to be in leading phase, and if these values occur after the corresponding values of the voltage wave, it is said to be in lagging phase.

EXERCISES

I. Make a written translation of the text.

II. Retell the text.

9. Triodes

When a third electrode is inserted between the filament and the plate, the vacuum tube is enabled to perform other operations. This electrode is called the control grid and is generally in the shape of laterally wound wire or mesh whose turns are spaced so as to permit a current flow from filament to plate. It is also insulated from other electrodes, its purpose being to control the flow of plate current. Because the grid is placed very close to the source of electron emission, a small change in any voltage supplied to the grid will have as great a controlling effect on the plate current as a relatively large change in plate voltage.

The quantity of electrons attracted to the plate depends upon the combined effect of the plate and grid charges. When the plate is positive, normally, and the grid voltage is made more and more negative, the plate is less able to attract electrons and the plate current decreases. The grid being made less and less negative, the plate can more easily attract electrons and the plate current increases.

EXERCISES

I. **Read and translate the text without a dictionary.**

II. **Retell the text.**

III. **Compare the diode and the triode.**

10. Pentodes

When still another grid is inserted between the screen grid and the plate, a five-element tube is formed. Its construction is similar to that of the control grid, and it is often connected to the cathode inside the tube. This third grid is called the suppressor grid. There are many combinations of these electrodes in other tubes, the tube itself varying only in the number and position of its electrodes.

As higher and higher voltages are applied to the tube, the electrons strike the plate with such velocity that they dislodge electrons from the plate material. This secondary emission wastes energy and lowers the efficiency of the tube.

To eliminate this waste, the suppressor grid is erected between the screen grid and the plate. It is generally connected to the cathode, which gives it a low negative potential. Electrons emitted by the plate are repelled back to the plate or suppressed.

All types of vacuum tubes are derived from one or more of the foregoing classes. Design and operation characteristics are merely altered to fit the tube for special types of service.

EXERCISES

I. **Read and translate the text without a dictionary.**

II. **Retell the text.**

III. **Compare different types of vacuum tubes.**

11. Elements of an A-F Amplifier

The a-f amplifier tube acts as a power converter taking continuous power from the battery or d-c source in the plate circuit and converting this power into a-c power. The converted power is used to set up a voltage across an impedance in the plate circuit for the case of a voltage amplifier, or to supply power to a load for the case of a power amplifier. For carrying out this function, each stage of an amplifier must be furnished with an input coupling device, an output coupling device, and the necessary sources of power to actuate the tube. For the case of a multistage amplifier the input coupling device of one tube may be the output coupling device of the tube ahead of it.

EXERCISES

I. Read the text.

II. Put 4 questions to the text and answer them.

12. The Neutron Is Discovered

The discovery that atoms could be transmuted stimulated nuclear research. Some years later beryllium was bombarded with alpha particles. The beryllium emitted a radiation that could penetrate many centimeters of lead. It was much too penetrating to be X rays from the beryllium. In 1932 it was proved that the penetrating particles, now called neutrons, have about the same mass as the proton, and that they are uncharged.

Neutrons exert no forces on nuclei or electrons excepting when they approach very closely (only short-range, cohesive forces act). Thus a fast-moving neutron can travel through billions of atoms without losing much energy.

Both fast-moving and slow-moving neutrons can be captured by nuclei. A neutron, captured by a nucleus, may make it unstable so that it becomes artificially radioactive.

EXERCISES

I. Read the text.

II. Make a short information about the discovery of the neutron.

13. What Is Radioactivity and How Is it Detected?

Radioactivity is a spontaneous nuclear change causing radiations of particles to be emitted. Radioactive changes, occuring in the nuclei of atoms, are not affected by ordinarily used chemical processes. For example, radium, "decays" just as rapidly in liquid air as in a hottest furnace. Chemical changes, having to do with the outer electrons of atoms, are very sensitive to temperature variations.

Alpha, beta, and gamma rays may be detected by the same three effects as X rays. They make some substances fluoresce, they "blacken" photographic films, and they ionize gases. Their ionizing effect is applied in many physical instruments. The gold-leaf electroscope is one of the simplest detectors. Ions, produced by rays from the test substance, are attracted to an insulated plate connected to the gold leaf. The rate of motion of the gold leaf measures the ionization current, and therefore the strength of the radioactive source.

EXERCISES

I. Read and translate the text.

II. Retell the text.

III. Translate the following sentences, paying attention to the different meanings of the word *make*:

1. Scientists *make* numerous experiments in studying radioactivity. 2. Scientists *make* the radioactive atoms disintegrate. 3. The synchrophasotron of the Soviet *make* is an invention of the utmost importance.

14. The Sun's Energy

Measurements of solar radiation reaching the earth each day not only make it possible to calculate the surface temperature of the sun but also to determine its total radiation. The fact of the sun, over a period of many years, showing no signs of cooling off, has long been an unsolved mystery. With the discovery of nuclear disintegration and the development of methods of producing many new types of atoms, this mystery has in a measure been recently solved.

Although there is no direct way known of observing the interior of a star like our sun, mathematical calculations based upon well established physical laws show that down deep within such a mass the temperature is so extremely high that matter must be a conglomeration of atoms, electrons, and light waves, all moving about at tremendously high speeds.

Near the center of the sun where the temperature is about 20 million degrees, the atoms are stripped of their electrons and the light waves produced there are of such high frequencies that they should be classified as γ rays and X rays. Here, where the average particle velocity is so high, nuclear reactions must be taking place on a large scale and the liberated energy must be filtering up through to cooler and cooler layers as light waves of lower frequency. At the surface most of the radiations escaping are of sufficiently low frequency to be classified as visible, ultraviolet, and infrared.

EXERCISES

I. Read and translate the text.

II. Tell about the sun's energy.

15. The Computer

A computer is a machine that can take in information, perform different operations and provide answers. A computer can perform logical and mathematical operations such as addition, subtraction, multiplication, division, and some more complex mathematical operations.

Logical operations deal with selecting, comparing, matching and so on meeting different needs of the users.

All the operations of a computer are performed at high speed in some kind of language (marks or symbols).

EXERCISES

I. Read and translate the text without a dictionary.

II. Speak about a computer, making use of the text.

16. A Pulse Logic System

In a dynamic or pulse logic system a bit is recognized by the presence or absence of a pulse. A 1 signifies the existence of a positive pulse in a dynamic positive-logic system; a negative pulse denotes a 1 in a dynamic negative-logic system. In either system a 0 at a particular input (or output) at a given instant of time designates that no pulse is present at that particular moment. In a "doublerail" system the variable appears on two leads. A pulse on one lead indicates that the variable has the 0 value, a pulse on the other lead signifying a 1. A system employing pulses for bits may be constructed with capacitive or transformer (a-c) coupling between stages, although d-c coupling may also be used with pulses. Most computers using pulses operate as synchronous systems since all operations are performed during definite constant intervals of time.

EXERCISES

I. **Read and translate the text.**

II. **Put three questions to the text and answer them.**

III. **Speak about pulses in dynamic systems.**

17. Digital (Binary) Operation of a System

A digital system functions in a binary manner. It employs devices which are permitted to exist in only two possible states. A transistor is allowed to operate at cut-off or in saturation, but not in its active region. A node may be at high voltage of, say, 12 ± 2 V or at low voltage of, say, $0 \pm \pm 0{,}8$ V, but no other values are allowed. Various designations are used for these two quantized states. In logic, a statement is characterized as "true" or "false". A switch may be closed or open. Binary arithmetic and mathematical manipulation of switching or logic functions are best carried out when two symbols, 0 (zero) and 1 (one) are involved.

EXERCISES

I. **Read and translate the text without a dictionary.**

II. **Put questions to the text.**

III. **Retell the text.**

18. The Teaching Machine

The teaching machine is a mechanical device which gives programmed instructions to students. The students see only one portion of the program at a time, and are to give an answer to this, the correctness of their answers being shown to them by the machine. Then a new portion is presented to them.

The purpose of the teaching machine is not teaching, but only presenting the program.

The application of teaching machines is growing from day to day.

EXERCISES

I. Read the text without a dictionary and retell it.

II. Put some questions to the text.

19. The Junction Transistor

A transistor is a device in which an input current controls an output current.

For the junction construction the first diode, or emitter, junction is biased in the forward direction. For the N—P—N unit this means the emitter is negative, and thus the emitter-junction potential barrier is lowered. Electrons enter the N region from the emitter, those of higher energy being able to pass over the small barrier into the P region — the barrier height and the number of these high energy electrons reaching the P, or base, region are a function of the emitter-base potential. In this operation the emitter barrier acts as electron velocity or energy filter much in the same way as does the grid in a vacuum tube.

EXERCISES

I. Read the text.

II. Put some questions to the text and answer them.

20. The P—N Junction

The control of the conductivity of germanium or silicon by the addition of traces of other elements has been discussed. N or P conduction can be obtained as desired by introducing first one kind of impurity, then another, into the growing crystal, giving regions of alternating N and P conductivity. Such junctions may also be formed by fusing the impurity material onto thin germanium wafers, or by wafer diffusion or electroplating the impurity material onto germanium or silicon. By careful manufacturing control the transition between two regions can be made quite abrupt.

EXERCISES

I. **Read and translate the text with the help of a dictionary.**

II. **Put some questions to the text and answer them.**

21. The Majority and Minority Carriers

The P—N junction may be shown to have rectification or diode properties. If an external emf were applied to a junction in the so-called reverse direction, with P region negative, the majority carriers on each side would be forced farther away from the junction, or the barrier layer would be thickened, leaving only a few thermally generated minority carriers in the barrier to produce a very small current i_0. In this case the diode presents a very high resistance with an additional capacitive component, due to the dielectric of the barrier layer between N and P regions.

EXERCISES

I. **Read and translate the text without a dictionary.**

II. **Speak on the junction transistors.**

22. The Point-Contact Transistor

In the point-contact transistor the forward-biased electrode is referred to as the emitter, the reversed-biased electrode being the collector, and the germanium or silicon element is the base. The unit uses an N-type semiconductor wafer about 0.5 mm thick, the two wire contacts being spaced about 0.05 mm (0.002 in).

The positive bias on the emitter immediately removes electrons from the valence bonds near the surface, creating holes. In fact the emitter is said to inject holes into the semiconductor, the emitter current being composed of electrons. The holes immediately diffuse toward the negative collector. In the process many holes may meet and recombine with the free electrons in the N-type base material. To reduce this loss of holes, the emitter and collector must be close-spaced.

EXERCISES

I. Read the text.

II. Put some questions to the text.

III. Speak on point-contact transistors.

23. Valence Bonds

Each atom of germanium or silicon in its lattice is joined to its four nearest neighbours by four valence bonds, each having two valence electrons, one from each atom. As a result each atom is surrounded by a stable shell of eight electrons, the atoms and electrons being held rigidly in place. Since no charges are free to move, then germanium and silicon in this stable condition will behave as insulators. The temperature being raised, kinetic energy is given to the electrons and a few of the valence bonds will be broken and these electrons will become free.

EXERCISES

I. Make a written translation of the text.

II. Make a retranslation of the text.

Part VIII
TEXTS FOR HOME READING

ELECTRONICS, SEMICONDUCTORS AND NUCLEAR PHYSICS

1. Secondary and High-Field Emission

Electrons may be given sufficient energy for emission by the mechanical impact of an electron or ion striking the surface. The phenomenon is called secondary emission, the emitted electrons being secondary electrons. The particles striking the surface and causing emission are primary electrons, or primary ions.

Secondary emission can be produced by bombardment of a material, whether conductor or nonconductor, by high-energy primary beams of electrons or other particles. The secondary electrons emitted will be attracted to any electrode of higher potential in the region and constitute a flow of charge from the surface, whereas the primary beam carries charge to the surface.

The average number of secondary electrons emitted per primary electron or particle striking the surface is referred to as the secondary-emission coefficient and given the symbol δ. Values of δ for some surfaces may exceed 10.

Secondary emission depends on the nature and work function of the surface. The energies of the emitted electrons are usually less than 20 ev, but the number of secondary electrons, or δ is a function of the primary energy, usually having a broad maximum at 400 to 600 ev primary energy.

Surface condition, as well as low work function, is important in materials for secondary emission, because of the emission being primarily a surface function. High emission materials are composite surfaces, similar in most respects to those used for photoemission. Cesium-cesium oxide is one of the best surfaces for high δ value, clean graphite being one of low δ value.

In some tubes *secondary emission is depended on for a source of electrons*[39]. In such tubes a coated cathode, similar to surfaces described, is bombarded by gas ions from the space and emits electrons necessary to maintain the discharge.

Such cathodes require no external heat source and are frequently called cold cathodes, although their operation temperatures may be high owing to bombardment.

If a high positive electric field is applied at the surface of a metal, it is found possible to pull electrons directly out of the material at ordinary temperatures. The electric field lowers the value of E_B, the surface barrier energy, and at field intensities of about 10^6 volts per cm emission increases to high values, this being highfield, or autoelectronic, emission. Partial lowering of the energy barrier by the applied field is noted at lower voltages, where it is known as the Schottky effect.

The electric field between two closely spaced electrodes, or a point and plane, or between a fine central wire and a surrounding cylinder may reach high values without high potentials. Special design precautions are necessary in high-voltage tubes for X-ray and rectifier service to prevent such field build-up and possible damage by the high currents associated with high-field emission.

2. Thermionic Emission

While experimenting with an evacuated tube containing a heated filament and a separate electrode, it was found that a current would be set up between them if the electrode were positive with respect to the filament, but not if it were negative. In the light of present knowledge this current is accounted for by the emission of electrons from the filament into the space surrounding it, and the attraction of these emitted electrons to the nearby electrode. The escape of electrons from the surface of a metal is comparable in many respects to the escape of molecules from a liquid during the process of evaporation. The situation is a little different, however, *because an electron about to leave the metal*[40] induces a positive charge on the surface behind it and hence is attracted backward toward the metal. This action gives rise to the idea of a potential barrier, somewhat like surface tension, which must be overcome before the electron can escape. The metal being heated, the electrons in it are given more kinetic energy, which assists them in passing the potential barrier at the surface. For each metal, there is a definite minimum amount of energy needed to release an electron from the surface, this energy being referred to as the work function of the metal.

The thermionic emission of electrons by a hot body is the operating principle of the modern electron tube, the simplest of these being the two-element tube, or diode. This device consists of an evacuated bulb or tube with a filament somewhat like that of an incandescent lamp, and a separate metal plate. The filament being heated to incandescence by battery A, it will emit electrons. These will be attracted to the plate when it is maintained positive by battery B, and the galvanometer will show a deflection. Should the plate be made negative by reversing battery B, the electrons evaporated from the filament would be repelled by the plate and, since no electrons would be emitted from the cold plate, the galvanometer would not show a deflection. Hence the electrons can flow only from filament to plate, or, what corresponds to the same thing, the conventional direction of current can be only from plate to filament. Consequently this electron tube acts as a rectifier, the plate being the anode and the heated filament the cathode.

The number of electrons emitted from the filament in a unit of time depends upon the substance it is made of and upon its temperature. The rate of electron emission is generally expressed as the current per unit of surface area of the hot body.

The current from plate to filament of an electron tube, is the steady value that results when the plate potential is high enough to sweep all the electrons from the region around the filament as fast as they are liberated, this being the so-called saturation current. At lower potential differences between the two electrodes of the tube the current will be less, because of some of the evaporated electrons being driven back into the filament by the negative charge that builds up in the space near the plate. The accumulation of electrons in this region of the tube is called the space charge. In most types of electron tubes it is not expedient to measure the saturation current, due to its value being so large as to change the emitting conditions or damage the tube.

3. Electrons in Metals

Thermionic emission may be defined as the process whereby electrons are freed from a solid or liquid when the latter absorbs energy in the form of heat. There are similar processes whereby electrons may be freed. It is the purpose of this text, therefore, to describe the nature of the metallic elements, to show how electrons behave in such elements, and to deduce under what circumstances electrons may be liberated from them. The four principal types of electron emission, viz., thermionic, photoelectric, secondary and field emission, will then be considered as special cases.

Electrons, Protons and Neutrons. To understand how valves and cathode-ray tubes work, it is necessary to know something about the electrons which give these devices their distinctive qualities and to understand something of the properties of electrons it is necessary to know a little about the atomic structure of matter.

All matter consists of atoms which contain electrons, protons and neutrons in a particularly intimate association. The electron has a negative charge of 1.60×10^{-19} coulomb. Its mass can be measured quite accurately, varying with its speed. When it is travelling at the speeds usually encountered in electronics, its mass is 9.1×10^{-13} kg. The proton has a positive charge equal to the negative charge carried by the electron, its mass being about 1840 times as large, being -1.66×10^{-27} kg. The neutron *as its name implies*[41], has no charge — it is electrically neutral — and its mass is roughly equal to that of the proton.

Atoms are made of these three "particles" in a very simple manner. Each element possesses a certain number of protons and an equal number of electrons. For example, the hydrogen atom has one proton and one electron; the sodium atom has eleven protons and eleven electrons; the chlorine atom has seventeen protons and seventeen electrons. The number of electrons must always equal the number of protons to keep the atom electrically neutral, each element being characterized by its number of electrons, or, as it is called, its atomic number.

Where then, it may be asked, do the neutrons come into this? Their role is much less important from one point of view than that of the protons and electrons. If an atom is weighed, it will be found to contain more mass than can be accounted for by the protons and electrons. For example, sodium, containing 11 protons and 11 electrons, weighs as much as 23 protons and 11 electrons, the remainder of mass (23—11) being accounted for by the neutrons. So the atom of sodium contains 11 electrons, 11 protons and 12 neutrons.

This picture of the atom accounts admirably for all its known properties. Hydrogen is the only element which has an atom devoid of neutrons. The commonest hydrogen atom is known to be simply one proton and one electron. Helium contains 2 protons, 2 neutrons and 2 electrons.

Atoms do not simply consist of a jumble of electrons, neutrons and protons. They are arranged in a very beautiful manner. The protons and neutrons comprising almost all the mass of the atom, are confined to an extremely small volume and together form what we call the nucleus. The electrons, on the other hand, are spread out in space around the nucleus in shells which have been compared to the orbits of the planets round the sun. The electrons can be stripped off the atom rather easily, leaving it positively charged, of course, but it is much more difficult to break up the nucleus.

4. Brief Survey of Transistor Physics

The atom of an element consists of a positively charged nucleus around which negatively charged electrons are circling. They possess energy in discrete amounts, and therefore they are placed only in certain energy levels with forbidden gaps between them. The farther an electron is from the nucleus, the higher is its energy. In the normal state, the electrons tend to fill the lowest energy levels, leaving only the highest energy level unfilled. Electrons in this outer valence shell are loosely bound to the nucleus and can be freed or tied to neighboring atoms, these valence electrons defining the chemical and electrical properties of the material.

In solids, atoms are known to be situated very closely to each other; neighboring atoms can derange their energy levels and combine to form energy bands. Only two of these bands are of interest to us in a solid — the valence band and the conduction band, where electrons can move and participate in an electric current. Between the valence and the conduction bands, there is a forbidden gap which the electrons can cross but where they cannot remain.

The charged carriers in the valence and conduction bands determine the electrical properties of the matter. In this regard we distinguish between insulators, semiconductors, and conductors. In an insulator, there are practically no free electrons, whereas in a conductor there are many to take part in electric current. The semiconductor's characteristics lie between these. The best-known semiconductors are germanium and silicon, each of which has four valence electrons in its outer shell. Germanium and silicon form a crystal structure in the form of a tetrahedron, all four valence electrons of each atom forming covalent bonds with the electrons from four neighboring atoms.

For this reason, the semiconductor crystal is an ideal insulator at the temperature of 0° K (absolute zero). However, temperature rising, more and more electrons in the valence band acquire sufficient energy to break the bonds and jump into the conduction band. In the valence band, each free electron leaves a hole which behaves like a positively charged particle. It attracts neighboring electrons and eventually recombines with one. The higher the temperature, the greater the number of electrons and holes that generate and recombine. However, on the average, there will be more free carriers, which can take part in an electric current. Thus, thermal energy is the cause of the intrinsic conductivity of semiconductors.

Chemically pure germanium can be doped with atoms of pentavalent elements which insert themselves into the crystal structure. Four of the five valence electrons of the pentavalent elements form covalent bonds with neighboring valence electrons of germanium atoms. There remains a fifth, excess electron which is free to take part in an electric current. The pentavalent atom donates an electron and is called a donor.

When pure germanium is doped with atoms of trivalent elements, their three valence electrons will form covalent bonds with neighboring valence electrons of germanium atoms. There remains a hole which can take part in an electric current. The trivalent atom accepts an electron and is called an acceptor.

A germanium crystal doped with impurities possesses extrinsic conductivity, whether the free carriers are electrons or holes. In the N-type germanium, the electrons are the majority carriers and the holes the minority carriers, whereas the opposite is true for the P-type germanium.

There are two reasons for the motion of free carriers in a semiconductor: first, the variable concentration of the carriers as they try to spread uniformly throughout the crystal (diffusion current); second, the tendency, under the influence of the applied voltage's electric field, of electrons and holes, in the form of drift current, to try to move towards the opposite poles.

5. Semiconductors

The electrical qualities of semiconductors lie half-way between those of insulators and conductors. Semiconductor material is not only characterized by its resistivity factor but also by the great influence that various factors, such as heat and light, have upon this value.

The semiconductor group is made up either of elements or of chemical compounds. These have four valence electrons in their outer shell. Two of these elements, germanium and silicon, are especially important.

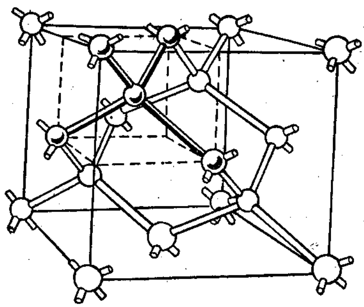

Fig. 26

All the elements of interest in semiconductor physics are given from the periodic table of elements. The group number is the number of valence electrons. With each element appears its chemical symbol and atomic number, which is the number of electrons within the atom.

Some intermetallic compounds between the trivalent and pentavalent elements behave like the tetravalent elements. These are the alloys of two metals, such as gallium arsenide, indium antimonide, and so on.

Finally, various oxides, notably copper and titanium oxides, behave like semiconductors. We shall also mention the element selenium, which does not belong to the fourth group of elements.

A germanium atom has 32 electrons. Of these, 28 are in the inner shells and 4 are in the outer shell. These four electrons in the valence band take part in any chemical reactions or electrical conductivity.

Suppose that we have pure (intrinsic) germanium which is first melted and then cooled. When germanium solidifies, it forms a crystalline structure referred to as the diamond type. Each atom is equidistant from four neighboring atoms, with the atoms forming tetrahedrons. In a crystalline structure each atom shares four valence electrons with the adjacent atoms, so that one electron is shared with one electron of the nearest atom. The resulting electron pairs are called covalent bonds. Covalent bonds are illustrated schemically in Fig. 26 by means of the rods connecting the adjacent atoms. It is easy to see that all the valence electrons of the atoms are bound in the crystalline structure. These covalent bonds can be disrupted only at the expenditure of some amount of energy — for example, the energy needed to break the covalent bonds in a germanium crystal is about 0.75 ev.

The ideally built crystalline structure is seldom found in nature. Usually there are some impurities that disturb the orderly structure. If crystallization takes place spontaneously or too quickly, many centers appear from which the process of crystallization develops, and a "breaking" surface forms. The resultant many-centered crystal is called a polycrystal. When we speak of an ideally built crystal, we understand this to mean a monocrystal, in which the crystal grows from one center.

6. Atomic Structure of Matter

The atom of any element consists of a positive-charged nucleus around which negative-charged electrons are circling, the number of electrons corresponding to the number of positively charged particles in the nucleus. From the outside, the atom appears to be electrically neutral. Because of their motion, the electrons possess a certain amount of kinetic energy, but the forces that hold them in their circular path are in equilibrium.

According to the concept of quantum mechanics, the electrons within an atom can possess only discrete amounts of energy, called energy quantums. Because the circular path of each electron is determined by its energy, the electrons are circling around the nucleus in predetermined paths or energy levels.

In a single atom, only a definite number of energy levels can exist and not more than two electrons can occupy the same energy level at one time. The greater an electron's energy, the farther it is from the nucleus; this increased distance means that the electron is loosely tied to the nucleus.

Between the energy levels, there are forbidden gaps in which the electrons cannot stay. If the electrons acquire enough energy from some outside source (temperature, light, and so on), they will jump to a higher energy level, passing the forbidden gap. On the other hand, if the electrons lose energy (for example, in collisions), they will fall to a lower energy level nearer the nucleus.

Electrons within an atom have the tendency to occupy the lowest energy levels when they possess a minimum of energy. Thus, the highest energy level, the outer shell, will remain unoccupied. An atom is in the normal state when electrons occupy and fill the lowest energy levels.

Electrons at the lower energy levels, the inner shells are very firmly tied to the nucleus. When external energy, in form of heat, light, or radiation, is brought within the atom, however, electrons in the inner shells may acquire enough energy to jump to higher energy levels. Such an atom is in the excited state.

The electrons in the outer shell are tied rather loosely to the nucleus and can be completely torn loose from their atomic bonds when acquiring a certain amount of energy. Such electrons completely separated from the nucleus behave as ordinary atomic particles with mass and negative atomic cores. An atom losing these electrons is in the ionized state.

An atom with an unfilled outer shell coming close to another atom tends either to completely fill its outer shell with outside electrons or to give away surplus electrons in its outer shell to the neighboring atoms. Thus, the atoms are tied together, forming a chemical compound, the number of electrons in the outer shell of the atom of an element determining the chemical properties (valence) of the element. Under certain circumstances, electrons from the outer shell can be freed and then take part in an electric current. The number of electrons set free and the electrical properties (resistivity) of the elements determine the amount of energy spent.

We can say that electrons in the inner shells take part in the atomic processes whereas the electrons in the outer shell take part in chemical and electrical processes.

In gases, single atoms are so far from each other that there is practically no influence among neighboring atoms to cause interference in the energetic arrangement within the atom. Two atoms coming close to each other, their energy levels will shift only slightly.

In solids, very large numbers of atoms are squeezed into a small volume and there is considerable interaction among them. The nucleus of one atom is known to attract electrons from neighboring atoms, electrons which were previously attracted only by the nucleus to which they were originally held. Thus, energy levels are changed. The energy levels split and overlap to form energy bands composed of many finite energy levels. In a single atom we know the electrons to be located at definite energy levels, whereas in solids the electrons are located in energy bands separated by forbidden gaps.

The only energy band of interest is the highest energy band or valence band. If a certain amount of energy is given to an electron in the valence band, the electron is freed from the atomic structure of the solid and jumps into the conduction band to take part in electric-current flow. Again, there is a forbidden gap between the valence and conduction bands; the electrons can pass through this region but cannot remain in it.

7. Transistors and Vacuum Tubes

The transistor is often better understood as part of an electronic circuit with the help of an analogy. It is now desirable to make a final comparison between two amplifying devices.

In vacuum tubes, the control of the electron flow is performed in a nearly perfect vacuum, whereas in the transistors the flow of charged carriers (either electrons or holes) is performed in a nearly perfect crystal lattice of a semiconductor. The vacuum tube can be represented as an equivalent resistor whose magnitude is changing with the variations of the control-grid bias; the result is the changing current and voltage across the load resistor in the output. Similarly, a transistor can be conceived as a variable resistor whose magnitude changes with variations of the base current. In fact, the name transistor, implying this concept, is a combination of the words transfer and resistor.

An analogy can be drawn between the functions of the electrodes of a transistor and the functions of a triode tube. The emitter can be compared to the cathode, the base to the grid, and the collector to the anode. A further analogy can be drawn with the basic configurations; the CE configuration corresponds to the grounded-cathode circuit, the CB configuration to the grounded-grid circuit, and the CC configuration to the cathode-follower. Moreover, the electrical characteristics of the transistor and the vacuum tube are very similar.

A precaution must be taken[42], however, with drawing further analogies, lest we come to wrong conclusions. It is always better to conceive the transistor as a separate device with its own physical phenomena.

It is, for example, wrong to simply compare the gains of a transistor and of a vacuum-tube amplifying stage. Often, our concepts about the electronic amplifiers come from the vacuum tubes. A general concept is that there is always a power gain with an amplifier. This principle is true for the transistor because its low input resistance must always consume a certain amount of energy in the input circuit. A vacuum tube, however, very often has an infinitely large input resistance with no power consumption at the input. Therefore, a vacuum tube as a voltage amplifier can be conceived only as a special case of the more generalized power amplifier.

Another example of the wrong conclusions that can be made with a formal analogy concerns the mutual conductance. Transistors have a g_m on the order of magnitude of 100 milliohms a very high figure in comparison with the mutual conductance of a normal vacuum tude. *The point is that*[43], because of the small input resistance of the transistor, the input voltage (defined, by the mutual conductance, as a ratio of the anode current to the control- grid voltage) is dependent upon other factors in the input circuit, that is, the internal resistance of the signal source. Therefore, in the case of the transistor, the input current has a greater meaning than does the input voltage.

From these two examples, we can see the basic difference in the application of a transistor or a vacuum tube. For this reason, we must take into consideration four parameters for the transistor, whereas only three are necessary for the vacuum tube. The output characteristics and the input characteristics are needed to comprise the four transistor parameters.

8. Advantages and Drawbacks of Transistors

In comparison with those of a vacuum tube, the advantages of the transistor are so great that it is reasonable to expect that transistors will replace vacuum tubes altogether. The main advantages of the transistor are the following:

1. Absence of filament power loss. Transistors have much better efficiency.
2. Long life. The life of the average transistor is 10,000 and even more operating hours.
3. Low operating voltages. Small batteries can be used.
4. Small dimensions. Circuits can be miniaturized.
5. Mechanical ruggedness.

One of the principal causes of damages in electronic circuitry is high temperature, the cathode of a vacuum tube being heatted to several hundred degrees centigrade above the ambient temperature. Not only does this heat cause breakdown of the tubes, but it also heats other circuit elements (resistors, electrolytic capacitors, and so on) that are very sensitive to this influence. The transistor, on the other hand, does not heat its surroundings to any appreciable extent. Because of its long lifetime and ruggedness, the transistor is very reliable and is indispensable in professional equipment.

However, the transistor has certain drawbacks:

1. A great sensitivity to temperature, either ambient or self-generated.

2. Production problems. It is difficult to reproduce the same electrical qualities in close tolerance for mass production.

3. A low gain at high frequencies.

Intensive research is being done to diminish or remove these drawbacks. Research has already produced the semiconductor materials that are not so sensitive to temperature. It is probable that new technology (using the diffusion process) will solve the problems of inexpensive mass production, cut-off frequencies, and power dissipation of transistors. Progress is also being made with the internal noise of the transistor, which is now as much as 60 db below that of earlier types.

9. The Tunnel Diode

The tunnel diode displays a useful negative-resistance characteristics. The tunnel effect controls the current at very low values of forward bias where the normal injected diode current is very small. The mechanism which controls the current is purely quantum-mechanical in nature. Fig. 27 illustrates the effect. There we find that there is a certain probability that an electron on one side of a potential barrier will leak through the barrier if the barrier is very thin. The barrier must be on the order of 100 A thick. In a p-n junction, it is possible to have such thin barriers if p-type and n-type materials are both very heavily doped. This makes the depletion region very narrow.

There is a second effect which the heavy doping has on the band structure which is important. The donor level widens and overlaps the edge of the conduction band.

The Fermi level also moves up into the conduction band. A similar phenomenon occurs in the p-type material, where the Fermi level moves into the valence band. Notice that the net tunneling is zero because of there being the probability of electrons going from states in the conduction band on the n side to states in the valence band on the p side as in the opposite direction.

The maximum current conditions being reached, all the electrons in the conduction band see empty states just across the barrier and a large amount of tunneling will take place.

The valence electrons in the p-type materials, however, see forbidden levels to the left and cannot tunnel.

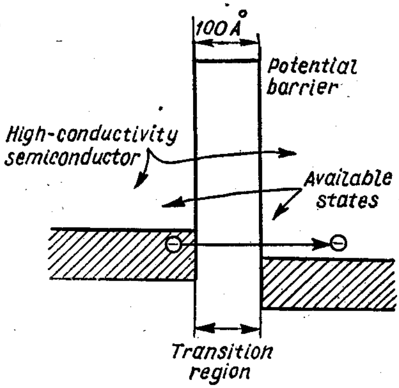

Fig. 27

Thus the tunneling current is smaller than above. This phenomenon, the suppression of the tunneling, makes the current decrease as the bias increases and thus causes the negative-resistance part of the diode characteristics.

Tunnel diodes have become very useful in high-frequency circuits because of tunnel current being carried by majority carriers which are very fast. There is very little capacitance associated with the junction, and the effects of temperature are small because of the Fermi level being so rigidly clamped in the allowed bands.

Applications of the negative-resistance characteristics of such a device as the tunnel diode look highly promising because of the relatively good stability of such devices and the simplicity of the circuits.

10. Nuclear Physics

Much of the research effort in present-day Physics is being focused on the nucleus of the atom, for the nucleus, because of its possessing definite electric charge and its concentration of mass, is the most important component of an atom. The nuclear charge, which establishes the identity of the atom, is altered spontaneously in a few elements through the process of natural radioactivity. All atoms can now be artificially transmuted by the recently developed techniques of Nuclear Physics. The alchemist's dream of making gold from the baser metals has indeed come true; not a transmutation by chemical means, which affect only the valence electrons of the atom, but by more powerful physical methods for penetrating the nucleus and changing its composition.

11. Radioactivity and Nuclear Energy

Roentgen's discovery of X rays in December, 1895, aroused wide interest and stimulated scientists to search for other penetrating radiations. Only four months later, the French physical chemist, Henri Becquerel, "struck gold". He knew sunlight to make some substances fluoresce like the glass walls of Roentgen's X-ray tube. He falsely guessed that the sunlight might stimulate such phosphorescent material to emit penetrating rays. Accordingly, he exposed several minerals to sunlight until they glowed, and placed them on photographic plates wrapped in paper. Only one of them, a uranium salt (uranium nitrate) blackened the plate. The winter sun did not shine for several days, and Becquerel left the uranium crystals on a photographic plate wrapped in paper. When he developed the plate, it was blackened even though the crystals had not been exposed to sunlight. Later experiments proved that anything containing uranium emits penetrating rays.

A young Pole, Marie Sklodowska, asked Becquerel's permission to investigate the new phenomenon for her doctor's degree. Having studied all the known elements, she proved only uranium and thorium to discharge an electroscope. Then she tried many compounds and mixtures. Pitchblende, a uranium ore, appeared to be more active than uranium. She reasoned that the ore must contain a new element. Thrilled at the thought, she and the eminent professor, Pierre Curie, whom she married, decided to isolate the element.

Having given two years of joyful service, they isolated two new elements. The first they called polonium for Madame Curie's native land. To the second they gave the name radium.

12. A New Discovery

In 1937 some scientists subjected uranium to the bombardment of neutrons and from the radioactivity produced believed they had succeeded, for the first time, in producing a series of new elements, 93, 94, 95, etc., beyond uranium, 92. The reason for their belief was that the uranium, after bombardment, gave off electrons with a number of different half-lives. Attributing these different half-lives to the successive disintegrations of the same atoms, a single nucleus should emit several electrons one after the other. With each emission the nuclear charge would increase by unity, thus producing an atom of higher and higher atomic number.

Although similar observations were later made by the Curie-Joliots, all observers seemed to have misinterpreted

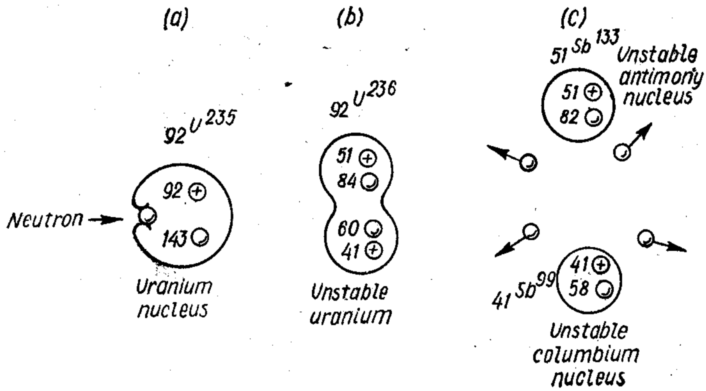

Fig. 28

the phenomenon because, in 1939, a new and important discovery was made. After bombarding uranium with neutrons, a series of chemical separations of the uranium sample was made to determine the element to which the newly produced radioactivity belonged. The radioactive atoms were found to be identical chemically to a number of different elements, nearly all of which are near the center of the periodic table. In other words, a uranium nucleus, after the capture of a single neutron, seemed to be splitting apart into two nearly equal fragments as illustrated in Fig. 28.

To explain the phenomenon in simple words, consider the details of the process illustrated in Fig. 28. An original uranium nucleus, U-235 with its 92 protons and 143 neutrons is shown at the left as it captures a slow moving neutron.

In the center diagram (*b*) the newly formed nucleus is unstable and starts to separate into two nearly equal parts, this separation process being called fission. In coming apart the uranium nucleus, behaving like the analogous waterdrop, splashes out small drops, this time neutrons not needed by the two fragment nuclei. So great is the energy liberated by this explosion of the nucleus that each of the two heavy nuclei fly apart in opposite directions.

Not all of the uranium nuclei divide into antimony and columbium as shown in the diagram but into any one of a number of pairs of fragments corresponding to elements near the center of the periodic table. The experimental evidence seems to favor pairs or slightly unequal mass, accompanied by

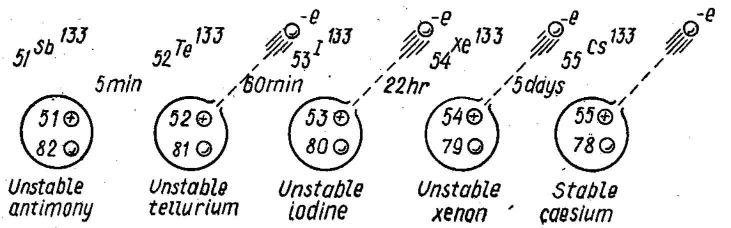

Fig. 29

from one to five or more neutrons as shown in Fig 28. The two fragments with nearly equal positive charges (+51 and +41 in the figure) are in general not stable nuclei, for they still contain an excess of neutrons.

To become stable each nucleus starts a series of β-ray emissions as indicated in Fig 29; finally ending up with a stable nucleus. Starting at the left in the diagram with the unstable antimony nucleus of charge +51 and mass 133 the successive emission of four electrons raises the nuclear charge by four unit steps ending with a stable caesium nucleus, $_{55}Cs^{133}$.

As proof that the above series are produced by fission, previously bombarded uranium has been chemically analyzed for elements near the center of the periodic table. After each chemical separation is performed a test of the β-ray activity is made by a measurement of the half-life. A comparison of this measured half-life with the values already known for the same element from other disintegration experiments has made it possible to identify some of the radioactive nuclei produced.

13. The Atomic Pile

Every achievement of science can bless or curse mankind. Atomic energy may kill or cure. Many peacetime applications use artificially radioactive nuclei manufactured in the atomic pile.

In order to understand how a pile operates, you must know how atoms of low atomic weight slow down neutrons. Suppose uranium-235 to be embedded in paraffin. Each neutron that strikes a hydrogen nucleus head on will stop like a billiard ball hitting another squarely. The neutron will lose all of its kinetic energy. In a slanting impact, the neutron will lose a considerable fraction of the energy, a substance of low atomic weight that slows down neutrons being called a moderator.

Graphite is used as a moderator in the atomic pile. It is cheap, can be highly purified, and can stand high temperatures. Some of the neutrons transform U-238 into neptunium, which becomes plutonium. Other neutrons bumping into the graphite nuclei get slowed down so that they split U-235 nuclei to liberate more neutrons and keep the "fire burning".

The berryllium rods absorb neutrons. Inserting these rods farther into the pile decreases the activity and dampens the "fire".

Coal must be supplied to a furnace, and ashes must be removed. Similarly, in the atomic pile, U-235 gets used up and plutonium accumulates. Also, the residues of the split atoms, which are now highly radioactive, increase in number, many of them absorbing neutrons and slowing the reaction. From time to time, the aluminum boxes are removed. Untouched by human hands, the contents are purified. Many of the by-product radioactive isotopes are useful in science and industry.

The atomic pile pours out many particles, including neutrons and gamma rays, usually the neutrons being absorbed by water and the gamma rays by concrete walls. People who work near a pile carry photographic films and small electroscopes to detect the deadly radiations.

14. The Neutrino

The neutrino is an amazing particle of matter with a special and unusual destiny. Its very name is unusual. In Italian it means "a small neutron". The birth of the neutrino was also unusual. It did not take place inside an atomic reactor or an accelerator: it was simply thought up a hypothesis. *It was not until several years later*[44], that its existence was proved.

The experiment was very complex. And no wonder, for the particle has no charge or mass. It is considered never to be in a motionless state but is constantly moving at the speed of light. The neutrino barely interacts with matter, hence its astounding properties of penetration.

The neutrinos freely escape in space taking with them a tangible amount of energy, from the depths of giant stars. Over 8 per cent of all the energy radiated by the Sun, escapes from it with neutrinos. Even at night the flow of neutrinos from the Sun goes through the mass of the Earth. This flow carries 40,000 times more energy than moonlight.

Some time after the discovery of the neutrino, it was found to have a double — an anti-particle, *for convenience sake it being called anti-neutrino*[45]. As a rule, particles and anti-particles differ from one another by the sign of their charge. But the neutrino has no electric charge. So in what way does it differ from the anti-neutrino? It differs, and this was proved in complex experiments, by its special "neutrino" non-electric charge.

Scientists in various laboratories are trying to discover this particle. Observations brought researchers to the conclusion that there exist not two, but four types of neutrino. The experiments have brilliantly proved this seemingly improbable hypothesis.

The neutrino and anti-neutrino appear to have pairs. At the suggestion of Bruno Pontecorvo, a Soviet Academician, they were christened muon-neutrino and electron neutrino. To solve the problem in what way these types of neutrino differ, the researchers must acquire powerful, controlled beams of high energy neutrons.

There is hardly any doubt that the neutrino might become the key for opening the door to the greatest secret of nature — the laws of the composition of matter, the laws of microcosmos.

Since the neutrino can easily penetrate the Earth or any planet and even any star, *it is the only accessible source of information as to what is going on in the depths of the Universe*[46].

The connection between the microcosmos and the cosmos is nowhere expressed more clearly than in physics of the neutrino. Inside the stars the neutrinos are formed in large amounts during nuclear transformation. Neutrino irradiation is supposed to provide all the heat to our Sun — a permanently operating thermo-nuclear reactor.

In any case the radiation of the neutrino is the factor which determines the evolution of the Sun, and, hence, the development of life on Earth as well.

RADIO ENGINEERING

15. Radio Waves

Electrical energy that has escaped into free space exists in the form of electromagnetic waves. These waves, which are commonly referred to as radio waves, travel with the velocity of light and consist of magnetic and electrostatic fields at right angles to each other and also at right angles to the direction of travel. One-half of the electrical energy contained in the wave exists in the form of electrostatic energy, the remaining half being in the form of magnetic energy.

The essential properties of a radio wave are the frequency, intensity, direction of travel, and plane of polarization. The radio waves produced by an alternating current will vary in intensity with the frequency of the current and will therefore be alternately positive and negative. The distance occupied by one complete cycle of such an alternating wave is equal to the velocity of the wave divided by the number of cycles being sent out each second and is called the wavelength.

The relation between wavelength λ in meters and frequency f in cycles per second is therefore

$$\lambda = \frac{300{,}000{,}000}{\varkappa},$$

the quantity 300,000,000 being the velocity of light in meters per second.

The frequency is ordinarily expressed in kilocycles, abbreviated kc, or in megacycles, abbreviated mc. A lowfrequency wave is seen from the above equation to have a long wavelength, while a high frequency corresponds to a short wavelength.

The strength of a radio wave is measured in terms of the voltage stress produced in space by the electrostatic field of the wave and is usually expressed in microvolts stress per meter. Since the actual stress produced at any point by an alternating wave varies sinusoidally from instant to instant, it is customary to consider the intensity of such wave to be the effective value of the stress, which is 0.707 times the maximum stress in the atmosphere during the cycle. The strength of the wave measured in terms of microvolts per meter of stress in space is exactly the same voltage that the magnetic flux of the wave induces in a conductor 1 meter long when sweeping across this conductor with the velocity of light. Thus the strength of a wave is not only the dielectric stress produced in space by the electrostatic field, but it also represents the voltage that the magnetic field of the wave will induce in cutting across a conductor. In effect, the voltage stress produced by the wave can be considered as resulting from the movement of the magnetic flux of the same wave.

The minimum field strength required to give satisfactory reception of the radio wave varies with the amount of interference that is present. Under the most favorable conditions it is possible to obtain intelligible signals from waves having a strength as low as 0.1 mv per meter, but ordinarily interfering waves generated by both man-made and natural sources draw out such weak radio signals and make much greater field strengths necessary. Thus experience has shown that in rural areas a field strength in the order of 100 mv per meter is required to give what the listener considers satisfactory service from a broadcast station, while in urban locations, where the man-made interference is much greater, a field strength of 5000 to 30,000 mv per meter is needed to insure good reception at all times.

A plane parallel to the mutually perpendicular lines of electrostatic and electromagnetic flux is known as the wave front. The wave always travels in a direction at right angles to the wave front, but whether it goes forward or backward depends upon the relative direction of the lines of electromagnetic and electrostatic flux. If the direction of either the magnetic or electrostatic flux were reversed, the direction of travel would be reversed, but reversing both sets of flux has no effect.

The direction of the electrostatic lines of flux is called the direction of polarization of the wave. If the electrostatic flux lines are vertical, the wave is vertically polarized; when the electrostatic flux lines are horizontal and the electromagnetic flux lines are vertical, the wave is horizontally polarized.

16. General Construction of Valves

The majority of valves can be classified without any understanding of their function or operation according to the number of electrodes they possess. By far the most popular design is one in which the electrodes are arranged as coaxial closed surfaces round the cathode, the simplest example being a series of coaxial cylinders.

This form has many advantages. First, the cathode emits over most of its surface, so that the maximum emission is obtained for a given heater power. Secondly, since the cathode and the grid are completely surrounded by the anode, all electronic action is confined to the tubular spaces between the electrodes. This avoids any interference due to electrical charge on the glass walls of the envelope.

The type of construction that brings all the leads to a valve base is almost universal. It is cheap and convenient, *lends itself to mass production*[47], and enables the valve to be "plugged" into a circuit by means of a suitable valve holder.

More complex valves may contain several gridded electrodes between the cathode and the anode or may, in multiunit valves, contain two cathodes and two complete sets of other electrodes. In all cases the attempt has been made to bring all the leads out through the base and, as a consequence, the valve holder has acquired considerable importance as circuit element.

For certain purposes even at comparatively low frequencies of operation, it is necessary to separate one electrode (usually the anode) as completely as possible from the remainder of the valve structure. It is then common practice to bring the particular electrode lead out through the top of the envelope (top cap anode or grid) by means of a flexible connection. Occasionally, it has been deemed advisable to bring both grid and anode connections out near the top of the valve. Such a valve presents certain difficulties in manufacture.

It should be noted at this stage that where the electrodes are only connected by thin leads to the outside of the valve, all the heat produced by the electronic action and the action of the heater must be radiated through the valve envelope.

17. Oxide-Coated Cathode

An oxide-coated cathode may be either directly heated in which case the core metal must take the form of a wire or a tape, or it may be indirectly heated in which case the coating may be attached to a surface of almost any shape. The directly-heated oxide-coated cathode differs only in its operating temperature from a corresponding thoriated-tungsten cathode. The power required to run it is smaller than that required for the thoriated cathode, the operating temperature being about 1,000° K. The voltage across the cathode need not be as large as in the other types. The most interesting cathode is the indirectly-heated cathode. In this case the temperature of the emitting surface is raised to the required value by means of a separate heating wire, usually enclosed in the emitting surface.

In a typical indirectly-heated cathode the heater wire is made up in the form of a bifilar spiral which fits into the hollow cathode and is insulated from it by a coating of alumina.

This form of cathode possesses many advantages. First, the cathode can be given the best shape for its purpose. Secondly, the cathode can be maintained at a given potential relative to earth; it no longer has a potential gradient along its length due to the heating current. Thirdly, since the insulation provided by the alumina is very good, the heater can be maintained at a different mean potential from the cathode and, by winding the heater non-inductively magnetic and electromagnetic effects due to using a heating current at power frequencies can be avoided.

In cathode-ray tubes and valves for ultra-high frequencies, disc-shaped cathodes must be employed. This can readily be done, using indirect cathode heating.

18. Tetrode Construction

Consider a triode valve to which a fourth electrode, a grid or mesh, has been added between the control grid and the anode, as in Fig. 30.

Let this second grid, S, called the screen, be connected to a d. c. supply at a voltage about two-thirds of that of the anode. Then the cathode, the control grid and the screen grid will act in much the same way as the cathode, grid and anode of a triode. That is, the electric field due to the potential of the screen will penetrate through the control grid to the cathode and will draw off some electrons, this current being actively controlled by the potential of the grid. But the electrons flowing towards the screen will not, in general, be absorbed there. Owing to the mesh structure of the screen, and to the higher potential of the anode, most of the electrons will flow past the screen so that the anode current will be controlled, just as the anode current in the triode is controlled, by the potential of the grid. The new construction, therefore, gives a new type of valve in which (i) the current to the anode is controlled by a grid as in the triode, and (ii) the anode itself is screened from the control grid by another electrode.

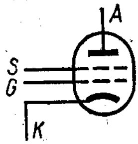

Fig. 30

The importance of the screen grid lies in the use which can be made of it to reduce very considerably the undesired grid-anode capacitance which makes the triode difficult to use at high frequencies. The effect can best be understood by considering the example of a simple screen-grid valve amplifier with a resistive load, as shown in Fig. 31.

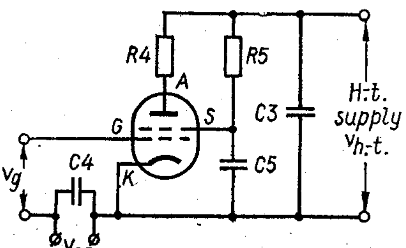

Fig. 31

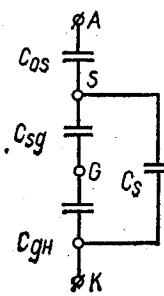

Fig. 32

Consider the screen-grid valve in which the screen S is maintained at a potential about two-thirds of that + h. t. by means of the resistance R_s in which there is a certain potential drop due to the electron current flowing to the screen. The capacitor C_s is chosen to be of such a value that it is a virtual short-circuit (zero impedance) at the signal-voltage frequencies. Therefore, although the voltage swing at the control grid varies the current flowing through the valve to both S and A, the capacitance C_s and the resistance R_s together maintain S at a constant potential. In fact, so far as the frequencies in the signal voltage are concerned, S is at earth potential. We have therefore interposed what is virtually an earthed electrode between the control grid and the anode without interfering too much with the current variations at the latter. This screens the anode effectively from the grid, and vice versa, reducing the capacitance C_{ga} to a very small value. *Another way of looking at it is that*[48] we have substituted for the usual triode capacitances those shown in Fig. 32.

The capacitances C_{kg}, C_{gs}, C_{sa}, have the usual values, given approximately by the valve geometry and of the order of 10 pF each. The capacitor C_s, introduced externally, may have any value we choose; it can always be made so large that the fraction of the current from A to S which flows through G is negligibly small.

It has been stated that the grid-anode capacitance in the tetrode is very small. It is not always negligible, however. At very high frequencies it is often necessary to use circuits to neutralize the feedback even in the case of tetrodes. Moreover, theoretically, at least, the grid anode capacitance sets a limit to the amplification which can be achieved by means of a tetrode at frequencies as low as a megacycle. The value of the capacitance varies from 0.005 to 0.001 pF.

19. The Vacuum-Tube Rectifier

A vacuum-tube rectifier or diode is used in nearly every radio and television transmitter and receiver to change alternating current into direct current (Fig. 33).

It consists of a highly evacuated glass bulb cantaining a wire filament that is heated electrically to incandescence. Surrounding the filament and connected to the outside through the tube base and a prong P_1 is a cylindrical metal plate P. When the filament is heated to incandescence it gives off large quantities of electrons in much the same way that water, when heated to the boiling point, gives off steam.

The emission of electrons by a hot body is called thermionic emission and is due to the high temperature and not to the electric current. Heating a metal by any other means will produce the same effect.

The principal action of the filament F and plate P is explained by means of a typical electric circuit shown schemically in Fig. 34. The circuit consists of a transformer having two secondary windings, a valve, and a load. The latter, shown as a resistance, represents any electrical device requiring unidirectional current for its operation. With an alternating current of 110 volts supplied to the primary, a high voltage, 240 volts for example, is delivered by one secondary to the terminals ED and a low voltage of 5 volts alternating current is delivered by the other secondary to the terminals CH. The latter, known as the filament winding, is for the purpose of heating the filament.

When for a fraction of a second the plate P of the tube is positively charged and the filament F is negatively charged, the electrons from F are attracted to the plate P and constitute a current flowing across the vacuum space PF and

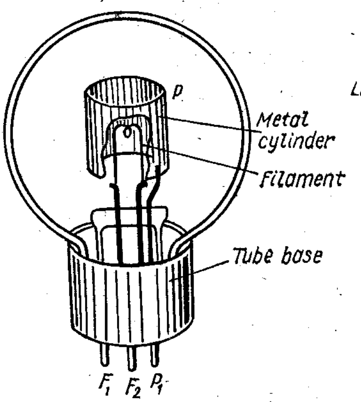

Fig. 33

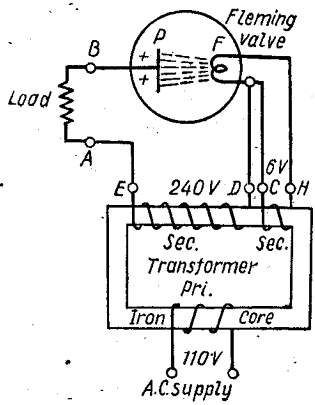

Fig. 34

through the load from B to A. One half cycle later, when the potential is reversed and P becomes negatively charged and F positively charged, the electrons from F are repelled by P and very little current flows.

20. The Pentode and Its Characteristics

In the beam tetrode the secondary electrons from the anode are prevented from reaching the screen by the repellant action of the space charge between screen and anode. This action can only occur when the anode is at a lower potential than the screen, but it is only under these circumstances that it is required. The anode being at a higher potential than the screen, it attracts its secondaries back to itself. In the beam tetrode the primary screen current is so small that the secondaries from the screen finding their way to the anode may be neglected.

The pentode is (as its name implies), a five-electrode valve. It comprises a cathode, a control grid, a screen grid and a coarse mesh grid between the screen and the anode, called the "suppressor". We know the function of the suppressor to prevent the interchange of secondary electrons between the screen and the anode, its action being very similar to that of the space charge in a beam tetrode, for it is maintained at cathode potential, repelling electrons coming towards it from either side. It is a conducting grid, depressing the potential between screen and anode.

The pentode valve is so extensively used nowadays, and in so many different ways, that an enormous amount of

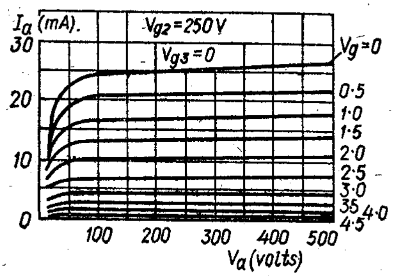

Fig. 35

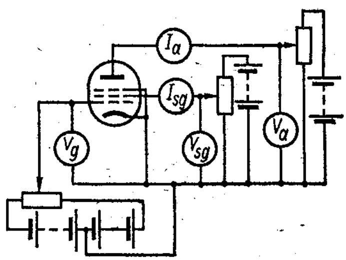

Fig. 36

effort has been directed towards improving its characteristics; and modern pentodes are designated to eliminate as far as possible, primary current to all electrodes except the anode. *There is another reason for doing this which has nothing to do with secondary emission*[49]: the unwanted noise produced by a valve amplifying a small signal depends to some extent on the division of current between the various valve electrodes. A good pentode amplifier for small signals should have the minimum screen and suppressor current. *Care is also taken in the design*[50] to cause the anode current to increase very rapidly as the anode voltage is increased from zero.

The anode-current grid voltage characteristics of the pentode are similar to those of the triode and the tetrode. The mutual conductance g_m defined as for the triode, usually lies between 1 and 10 mA/V, depending upon the cathode area. The anode voltage has practically no effect on the anode current, since the anode is screened from the cathode by no fewer than three grids. The screen voltage, on the other hand, has an effect comparable to that of the anode of a triode.

Fig. 35 shows a typical set of pentode Ia — Va characteristics, each curve corresponding to a given negative-grid voltage Va. They are drawn for a screen voltage of 250 volts, the suppressor grid being directly connected to the cathode. The circuit which might be employed to measure any pentode characteristic is shown in Fig. 36.

The fact that the anode current is almost independent of the anode voltage gives the pentode one of its important properties as an amplifier; it causes the dynamic resistance of the anode to be extremely high. This is rarely less than 100,000 ohms and may be as high as 1.5 megohms. This property makes for an improved amplification, and being of the order of 1,000 is about ten times what can be expected from a high-mu triode.

21. Oscillators

An oscillator is a device which produces a regularly-recurrent waveform of voltage or current and it comprises two basic elements — an amplifier and a frequency determining circuit.

The most common oscillator produces an output waveform, the latter approaching the sinusoidal very closely and comprises a valve and a tuned circuit. An amplifier valve with a parallel tuned circuit in its anode lead is known to give an amplification A at a resonance frequency of the tuned circuit, at this frequency the anode voltage being in phase opposition to the grid voltage. If a fraction 1/A of the anode voltage is taken, reversed in phase, and fed to the grid, the grid voltage is obtained from the anode voltage. The attenuation and phase reversal can be obtained by including a small coil in the grid circuit and coupling it to the anode coil.

With such a circuit, oscillation starts up at a small amplitude and builds up until the non-linearities of the valve limit its growth. These non-linearities are found to play an essential part, *one of the more important of them coming into action*[51] through the use of an automatic grid-bias current. The amplitude of the oscillation increasing, so does the grid voltage and hence the grid bias. The increasing bias reduces the mutual conductance of the valve and so the amplification, and *an equilibrium condition is at length reached*[52] at which a steady amplitude of oscillation is generated.

All types of valves can be used as oscillators, the triode being the most commonly employed, although in some circumstances a pentode is advantageous.

22. Cathode-Ray Tubes

The purpose of the cathode-ray tube is to show visually how certain electrical quantities, such as a voltage or a current, or both, vary with time. Since it is nowadays possible, *by some means or another*[53], to transform any physical parameter into a voltage or a current, the cathode-ray tube is extensively used to exhibit the variation with time of any physical quantity. The applications of the c. r. tube cover the whole field of science, and in television it has also become an adjunct to visual art.

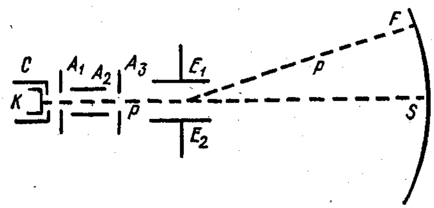

Fig. 37

All applications of the c. r. tube require the same basic elements. The elements of a c. r. tube may be listed as follows:

a) a means of producing a narrow beam of electrons;

b) a means of varying the intensity of (or electric current in) the beam or, using other words, a means of modulating the beam;

c) a means of making visible the small area where the beam impinges upon the end of the tube, the active area which can become luminous where the beam strikes it being known as the screen;

d) a means of deflecting the beam by applying to the tube a voltage or a current; i. e. deflecting plates or coils.

The beam of electrons in the form of a narrow pencil, P (see Fig. 37) is brought to a focus, F, on the screen, S, by means of an electron-lens system.

The spot, F, is then caused to move across the screen by the application of deflecting forces. These may be due to the electrostatic field between the plates E_1 and E_2, across which there is a potential difference, V_o. On the other hand, the deflection may be caused by the magnetic field due to a pair of coils carrying a current, and not shown in the diagram. The spot where the beam strikes the screen is made visible by means of a thin layer of luminescent material deposited on the inside surface of the glass end of the tube. By using two deflecting systems the spot may be made to traverse the screen in two dimensions, its path depending upon the voltage or current applied to the deflecting plates or coils.

23. The Electron Gun

An electronic device which shoots electrons at a particular speed in a particular direction is known as an electron gun. But whereas an ordinary gun shoots out projectiles one at a time, an electron gun shoots out anything from 10^{12} to 10^{20} electrons per second. An electron gun is an essential part of every cathode-ray tube and klystron; it is finding new uses every day in television camera tubes, travelling-wave valves and storage tubes.

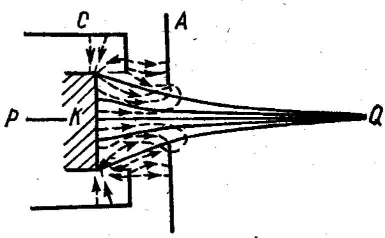

Fig. 38

The arrangement of electrodes in an electron gun is of greatest importance. A simple example of this is shown in Fig. 38 where all electrodes are supposed to possess cylindrical symmetry about the line P. Q. K is the disc cathode, surrounded by the coaxial cylinder C, known as the control electrode. This has an aperture opposite the cathode and about the same size. Facing the end of this cylinder is the plane anode, A, having a smaller coaxial aperture. The control electrode is maintained at a potential equal to or negative with respect to K, the anode being maintained at high positive potential. Assuming for example C to be negative with respect to K, the lines of force are shown by the dotted lines in Fig. 38, the arrows showing the direction of the forces acting on an electron. An electron leaving the cathode finds itself in a field accelerating it parallel to the axis and radially towards the axis. But as it nears the anode, the radial field diminishes and finally reverses in direction, so that the electron tends to move away from the axis.

The slow moving electron near K is deflected more towards the axis than the fast-moving electron near A is deflected away from it: hence the over-all action of the gun is to produce a converging beam. Indeed, the effect of the gun is to bring all the electrons leaving the cathode to an approximate focus at Q on the axis.

Two important points should be noted. First, the space charge in the vicinity of the cathode modifies considerably the electrostatic field so that the lines of force cannot be exactly drawn by normal geometrical means. This modifies to some extent the action of the gun. Secondly, the negative potential on the control electrode may have such a considerable effect that the focus F may actually occur between the two apertures, or almost exactly at A.

24. Push-Pull Amplifier

Imagine two identical valves connected as shown in Fig. 39 so that the signal to be amplified can be introduced across.

One can see the anodes be connected together through two equal resistors R_1.

The two valve cathodes are connected directly together, the two grids having a common standing bias applied at the centre-tapping of the coil $G_a G_b$.

The anodes have a common h. t. supplied at the mid-point of the resistance $2R_1$. Such a combination of two valves is known to be a push-pull amplifier although, in practice, the anode load is seldom a resistor. It is either a tuned circuit (for radio-frequency amplification) or a trasformer (for audio-or video-frequency amplification). The class A push-pull amplifier greatly reduces second-harmonic distortion and, in the limit, can amplify signals of almost double the amplitude which could be handled by each valve separately. This cannot be done by using the same two valves in any other way.

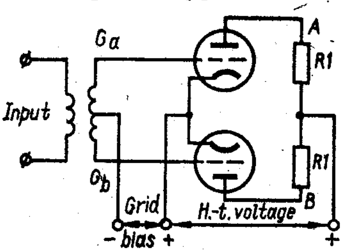

Fig. 39

To understand the operation of the class A push-pull amplifier first imagine that the signal amplitude is V/2 and the common standing bias is $-V_{\text{вm}}/2$. Then each valve will give a distorted output, but the voltage across AB will be virtually undistorted. The reason is that in the anode circuit the second-harmonic components of current flow in opposition to one another in the two resistances, while the fundamental components are in phase.

The voltage developed across the resistances by these currents each comprises a fundamental and second-harmonic component. *Viewed across the two resistances together, however*[54], between the points AB, the fundamental components of voltage add, whereas the second harmonic components cancel.

25. Television-Camera Tubes

The Iconoscope. The iconoscope is the simplest camera tube to explain, but in its original form it suffered from many defects. Fig. 40 shows the essential features of the elementary form. An image of the visual picture is formed by the lens system, L, on the screen, S. This screen consists of a fine mosaic of small photoelectrically active surfaces, each insulated from its neighbours. Each element of the mosaic emits electrons, its final electric charge depending upon the intensity of the light falling upon it. Thus a replica of the visual pic-

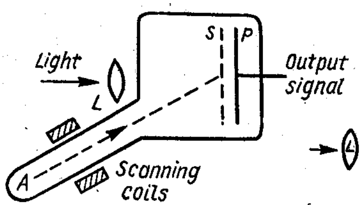

Fig. 40

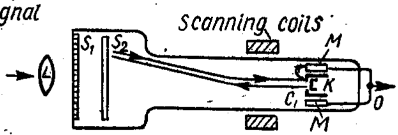

Fig. 41

ture is obtained in terms of electric-charge density. Immediately behind the photoelectric screen is a metal plate, P, insulated from the elements of the screen, but forming with the latter a multiplicity of capacitors. The quantity of electricity on each element, due to illumination of the screen, depends not only on the intensity of the light, but on the capacitance due to the proximity of the plate, P. For, only if each elemental capacitance were infinite, would the voltage remain zero for all light intensities, and only under these circumstances would the charge be exactly proportional to the light intensity. With a finite capacitance, the voltage change produces a decrease in the photoelectric current which becomes more marked the greater the voltage. It is, therefore, desirable that the elemental capacitances should be as large as possible.

A conventional cathode-ray tube is included in the iconoscope at A, arranged so that the beam may be caused to scan the screen, S. The beam traversing each element, it partially discharges it, and an electric impulse is transmitted to the plate, P. This impulse constitutes the outgoing electric signal from the iconoscope.

The most critical part of the iconoscope is the photoelectric screen and the method of manufacture is one requiring careful control. The mosaic consists of small globules of silver with a caesium surface on a mica sheet. The electrode P is a continuous conducting layer of silver on the opposite side of the mica sheet. The globules are very small compared with the cross-sectional area of the cathode-ray beam which scans the screen and consequently many globules are irradiated simultaneously by the electrons. Neglecting many complicating factors, the light falling on the mosaic gives rise to photoelectric emission so that each globule tends to become positive; it loses electrons. The scanning beam restores the original electron density, simultaneously giving rise to a pulse of current in the circuit connected to the plate, P. The complications are due to space charge and to secondary emission. Taking these into account, the iconoscope is not as sensitive as might be expected and is very insensitive at high light intensities. The variation in light intensity over the screen is not correctly reproduced by the electric signal.

The Image Orthicon. One of the most interesting devices, combining photoelectric action, secondary-electron multiplication and electron-beam scanning, is the image orthicon which is a very sensitive television camera tube. Fig. 41 shows diagrammatically how the device operates.

An image of the picture is formed by the lens system, L, on the continuous photoelectric surface, S_1, on the end of the tube. Immediately opposite this photoelectric surface and not far from it is a double mosaic, S_2, usually called the target. The photoelectrons emitted by S_1 move directly under the influence of a strong electric field to S_2, where they produce secondary electrons on impact. This secondary-electron emission charges the mosaic and produces an electric-charge picture corresponding to the visual picture. At the other end of the image orthicon is an electron gun from which electrons are directed towards the target. By means of magnetic coils the beam is made to scan the second mosaic of the target in the usual fashion. This scanning beam is comprised of low-velocity electrons: indeed the velocity is adjusted so that the elements of the mosaic reflect the electrons where no light has fallen on the corresponding part of S_1, but collect the electrons where the light has been intense. There is therefore an electron current from the target towards the electron gun, and the focusing and scanning coils bring this return beam to the first collecting electrode, C_1. This is the first electrode of a secondary-emission multiplier, M, the final electrode of which is the output terminal, O_1 so the reflected beam gives rise to a very much amplified current at the output.

The image orthicon is extremely sensitive and is easy to set up and to use. By substituting a screen sensitive to infra-red radiation for one sensitive to visual radiation, an infra-red camera tube is immediately available.

COMPUTING TECHNIQUE

26. The Definition of Mechanical Brain

When we speak of a machine that thinks, or a mechanical brain, what do we mean? Essentially, a mechanical brain is a machine that handles information, transfers information automatically from one part of the machine to another, and has a flexible control over the sequence of its operations. No human being is needed around such a machine to pick up a physical piece of information produced in one part of the machine, personally move it to another part of the machine, and there put it in again. Nor is any human being needed to give the machine instructions from minute to minute. Instead, we can write out the whole program to solve a problem, translate the program into machine language, and put the program into the machine. Then we press the "start" button; the machine starts whirring; and it prints out the answers as it obtains them. Machines that handle information have existed for more than 2000 years.

How should we imagine a mechanical brain? One way to think of a mechanical brain is shown in Fig. 42. We see here a railroad line with two stations, marked input, storage, computer, and output. These stations are joined by little gates or switches to the main railroad line. We can imagine that numbers and other information move along this railroad line, loaded in freight cars. Input and output are stations where numbers or other information go in and come out, respectively. Storage is a station where there are many platforms and where information can be stored. The computer is a special station somewhat like a factory; when two numbers are loaded on platforms 1 and 2 of this station and an order is loaded on platform 3, then another number is produced on platform 4.

We see also a tower, marked control. This tower runs a telegraph line to each of its little watchmen standing by the gates. The tower tells them when to open and when to shut which gates.

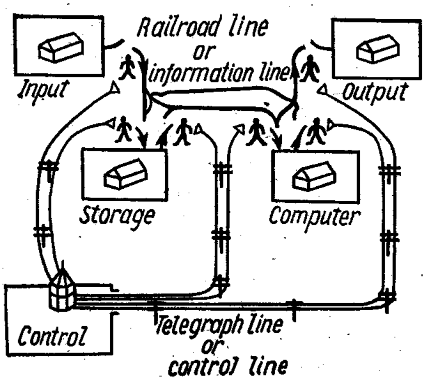

Fig. 42

Now we can see that, just as soon as the right gates are shut, freight cars of information can move between stations. Actually the freight cars move at the speed of electric current, thousands of miles a second. So, by closing the right gates each fraction of a second, we can flash numbers and information through the system and perform operations of reasoning. Thus we obtain a mechanical brain.

In general, a mechanical brain is made up of:

1. A quantity of registers where information (numbers and instructions) can be stored.
2. Channels along which information can be sent.
3. Mechanisms that can carry out arithmetical and logical operations.
4. A control, which guides the machine to perform a sequence of operations.
5. Input and output devices, whereby information can go into the machine and come out of it.
6. Motors or electricity, which provide energy.

27. Languages

As everyone knows, it is not always easy to think. By thinking, we mean computing, reasoning and other handling of information. By information we mean collections of ideas — physically, collections of marks that have meaning. By handling information, we mean proceeding logically from some ideas to other ideas — physically, changing from some marks to other marks in ways that have meaning. For example, one of your hands can express an idea: it can store the number 3 for a short while by turning 3 fingers up and 2 down. In the same way, a machine can express an idea: it can store information by arranging some equipment. As early as 1949 mechanical brain could store 132 numbers between 0 and 99,999,999,999,999,999,999,999 for days. When you want to change the number stored by your fingers, you move them: perhaps you need a half second to change the number stored by your fingers from 3 to 8, for example. In the same way, a machine can change a stored number by changing the arrangement of some equipment.

Since it is not always easy to think, men have given much attention to devices for making thinking easier. They have worked out many systems for handling information, which we often call languages. Some languages are very complete and versatile and of great importance. Others cover only a narrow field — such as numbers alone — but in this field they may be remarkably efficient. Just what is a language?

Every language is both a scheme for expressing meanings and physical equipment that can be handled. For example, let us take spoken English. The scheme of spoken English consists of more than 150,000 words expressing meanings, and some rules for putting words together meaningfully. The physical equipment of spoken English consists of (1) sounds in the air, and (2) the ears of millions of people, and their mouths and voices, by which they can hear and speak the sounds of English. For another example, let us take numbers expressed in the Arabic numerals and the rules of arithmetic. The scheme of this language contains only ten digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 or their equivalents, and some rules for combining them. Sufficient physical equipment for this language might very well be a ten-column desk calculating machine with its counter wheels, gears, keys, etc. If we tried to exchange the physical equipment of these two languages, we would be blocked: the desk calculating machine cannot possibly express the meaningful combinations of 150,000 words, and sounds in the air are not permanent enough to express the steps of division of one large number by another.

28. Machines that Think, and what They Might Do for Men

The pen is mightier than the sword, it is often said. And if this is true, then the pen with a motor may be mightier than the sword with a motor.

In the Middle Ages, there were few kinds of weapons, and it was easy for a man to protect himself against most of them by wearing armor. As gunpowder came into use, a man could no longer carry the weight of armor that would protect him, and so armor was given up. But in 1917, armor, equipped with a motor and carrying the man and his weapons, came back into service — as the tank.

In much the same way, in the Middle Ages, there were few books, and it was easy for a man to handle nearly all the information that was in books. As the printing press came into use, man's brain could no longer handle all recorded information, and the effort to do so was given up. But in 1944, a brain to handle information, equipped with a motor and supporting the man and his reasoning, came into existence — as the sequence-controlled calculator.

There are two questions we need to ask: What types of machines that think can we foresee? What types of problems to be solved by these machines can we foresee?

The machines that already exist show that some processes of thinking can already be performed very quickly:

Calculating: adding, subtracting, ...

Reasoning: comparing, selecting, ...

Referring: looking up information in lists, ...

We can expect other processes of thinking to come up to high speed through the further development of thinking machines.

29. Automatic Translator

Another machine that we can foresee would be used for translating from one language to any other. We can call it an automatic translator. Suppose that you want to say "How much?" in Swedish. You dial into the machine "How much?" and press the button "Swedish", and the machine will promptly write out "Hur mycket?" for you. It also will pronounce it, if you wish, for there would be little difficulty in recording on magnetic tape the pronunciation of the word as spoken by a good speaker of the language. The machine could be set to repeat the pronunciation several times so that the student could really learn the sound. He could learn it better, probably, by hearing it and trying to say it than he could by using any set of written symbols.

30. What Is a Digital Computer?

What is a digital computer? Is it a lightning calculator which can multiply two 10-digit numbers in the time it takes a jet plane to fly 1 inch? *Is it a data-processing machine which can automatically spew out yards of accurate and complete business reports*[55]? Or is it a device which can make decisions and check its own work? Or a device which accepts a set of thousands of instructions and then faithfully executes them in the appropriate sequence without outside help?

The digital computer is all these and more. It is more because its complicated mechanism is composed of simple, basic elements; because it applies the rules of logic to simulate many of the functions of the human brain; and because of its fantastic accuracy, reliability, and flexibility.

In what way is a digital computer different from the many calculating machines man has devised ever since he learned how to count? Before we can discuss the digital computer itself, we must know what is meant by a digital device.

The simplest digital device is any device which can count. The simplest of all counting devices are the ten figures. As a matter of fact, the word "digital" is derived from the latin *digitus*, which means *finger*. Another simple digital device is the clock. It ticks away, or counts, little bits of time called seconds.

In ancient days man learned to substitute beads for fingers in order to help him count. He built a counting board which consisted of several stiff wires mounted on a wooden frame, with ten sliding beads on each wire. By moving a certain number of beads toward the bottom of the board, any digit from 0 to 9 can be placed on each of the wires. Even 10 can be placed on a wire.

The ancient Chinese simplified the counting board into the abacus. Instead of ten beads on each wire, the abacus has seven. Two beads are mounted above a dividing wooden member, and five beads are mounted below the wooden member. All beads are in neutral position when they are furthest from the dividing member. Each of the lower beads has a value of one; each of the upper beads has a value of five.

The Japanese made the abacus more efficient. They used only five beads: four 1-unit beads below the dividing member and one 5-unit bead above.

31. Mechanical and Electronic Calculating Machines

A great step forward in the art of adding mechanically was made by Blaise Pascal in 1642. Pascal used wheels divided into parts instead of wires holding ten beads. The ten-part wheel can be compared to the wire with the ten beads bent so the two ends meet, the wheel representing a great improvement over the bead-holding wire.

Modern mechanical calculating machines also use wheels. Electric motors cause the wheels to turn at a rapid rate, yet the basic principle behind modern calculators is the same as that used by Pascal in his machine. An important achievement has been made, namely, electric power is substituted for hand power.

To speed up the counting process, electronic devices may be substituted for mechanical wheels. By shifting electrons from one place to another for each unit of the digit, the same counting effect can be produced as by moving a bead at a time, or turning a wheel a division at a time.

Why should a machine using moving electrons be so much faster than one using mechanical wheels? The answer to this question is very simple. The speed with which anything can be made to move depends on its weight, and the weight of an electron is practically nonexistent when compared to any mechanical gadget. Thus, with very little energy applied, electrons can be made to travel at tremendous speeds.

With machines of such lightning speed, it becomes ridiculous to have the operator feed it one problem at a time. Therefore, a logical control was built into the computer. This logical control enables the machine to accept a complete routine of instructions at one time, and then perform each instruction in the proper sequence. As a matter of fact, the logical control enables the machine to accept generalized instructions which can cause it to perform more operations than are actually fed into the machine.

In fact, the tremendous speeds at which these machines can work, and the flexibility built into them due to the logical control, make modern electronic digital computers a thousandfold more powerful than mechanical calculators.

32. Functional Organization of the Computer

The big problem in understanding digital computers is the logic which ties the logical elements into a unit performing arithmetic and logical operations.

Fortunately, all computer operations can be grouped into five functional categories. The method in which these five functional categories are related to one another represents the functional organization of a digital computer. By studying the functional organization, a broad view of the computer is obtained, it aiding materially in the study of the detailed logic.

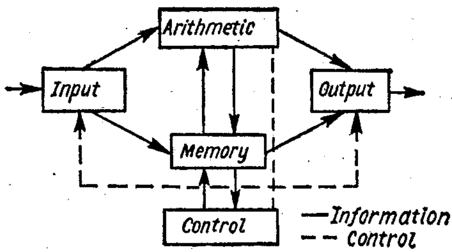

Fig. 43

The five major functional units of a digital computer are:

1. INPUT — To insert outside information into the machine.
2. MEMORY — To store information and make it available at the appropriate time.
3. ARITHMETIC — To perform the calculations.
4. OUTPUT — To remove information from the machine to the outside.
5. CONTROL — To cause all parts of the computer to act as a team.

Fig. 43 shows how the five functional units of the computer act together. A complete set of instructions plus data is usually fed through the input equipment to the memory where it is stored. Each instruction is then fed to the control unit. The control unit interprets the instructions and issues commands to the other functional units to cause operations to be performed on the data. Arithmetic operations are performed in the arithmetic unit, and the results are then fed back to the memory. Information may be fed from either the arithmetic unit or the memory through the output equipment to the outside world.

33. Machine Language and Programming

The five units of the computer must communicate with each other. This they do by means of a machine language which uses a code composed of combinations of electric pulses. These pulse combinations are usually represented by ZEROS and ONES where the ONE may be a plus pulse and the ZERO a minus pulse; or the ONE may be a pulse and the ZERO a no-pulse.

Numbers are communicated between one unit and another by means of these ONE—ZERO or pulse — no-pulse combinations. The input has the additional job of converting information fed in by the operator into machine language. In other words, it translates from our language into the pulse — no-pulse combinations understandable to the computer. The output has the additional job of converting the pulse — no-pulse combinations into a form understandable to us, such as a printed report.

In addition to data, the input translates instructions needed to perform a given problem into pulse — no-pulse combinations. These instructions are originated by a programmer whose job it is to translate a scientific or business problem presented in human language into a sequence of detailed instructions understandable to the machine.

34. Words and Numbers

There are languages based on words. We do have languages based on numbers. Word languages and number languages are similar in many respects. Word languages are built from letters which are combined into words. Relationships among these words are expressed by means of the rules of grammar. Number languages are built from digits which are combined into numbers; relationships among these numbers are expressed by means of the rules of arithmetic (+, —, ×, :).

Some words are related to each other by rules of spelling or of grammar. But many words are unrelated. All numbers, however, are related by a scheme of counting.

Because number languages are built on a firmer foundation, they are much more reliable for reasoning than are word languages.

35. Practical Logical Elements

In a practical machine, propositions or classes are represented by signals. As these signals progress from one stage to the next, they lose energy. Amplifiers restore this energy.

If a signal is produced now but must be applied to a certain circuit a little later, the signal waits in a storage device.

Amplification. There are in general two types of amplifiers: those that invert the polarity of the input signal and those that do not. The first is called an inverting amplifier and the second is called simply an amplifier. The amplifier and inverting amplifier blocks are shown in Fig. 44. Amplifiers perform various other jobs, especially in relation to memories. Symbols may be placed within the triangles to distinguish among several types of amplifiers.

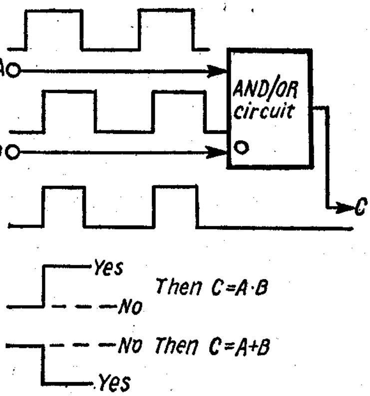

Fig. 44

Storage. The importance of time in computer logic may be illustrated by means of a diagram which also shows how the same circuit may at times be an AND circuit and at other times an OR circuit. This illustration is given in Fig. 45. Applied to terminals A and B of the device are two waveforms, each varying differently with time. The device produced an output waveform at C which is positive only when both A and B are positive and negative at all other times. If the positive portions of the waves are taken to represent ONE and the negative portions ZERO, then the device is an AND circuit. If the negative portions of the waves are taken to represent ONE and the positive ZERO, then the device is an OR circuit.

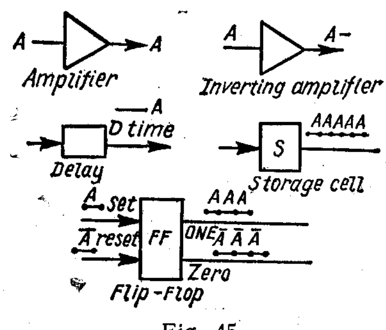

Fig. 45

Time is taken care of by storage. Storage may be represented in block diagrams in several ways, some of the more common blocks being the time delay, the storage cell, and the flip-flop. Time delay implies that the signal is delayed for a definite amount of time before being applied to another point in the circuit, whereas a storage cell holds a bit for an indefinite time, until called for. Logical blocks representing delay and the storage cell are shown in Fig. 45.

Also shown in Fig. 45 is the flip-flop. The flip-flop is a versatile storage cell. It has two input lines labeled "set" and "reset"; and two output lines labeled ONE and ZERO. A signal applied to the set line produces a continuous ONE output. A signal applied to the reset line removes the information from the ONE output line and causes the ZERO output line to produce a continuous signal. In the first instance, the flip-flop is set; in the second case it is reset. The flip-flop remains in one of these two stable states until a signal flips the flip-flop to the opposite state. But in either state, the two output lines produce signals that are out of phase with each other. This means that the flip-flop produces a signal and its complement simultaneously.

36. Some Features of a Digital Computer

Even in a large-scale digital system, such as in a computer, or in a data-processing, control or digital-communication system, there are only a few basic operations which must be performed. These operations, to be sure, may be repeated very many times. The four circuits most commonly employed in such systems are known as the OR, AND, NOT, and FLIP-FLOP. These are called logic gates or circuits.

An electronic digital computer is a system which processes and stores very large amounts of data and which solves scientific problems of numerical computations of such complexity and with such speed that solution by human calculation is not feasible. We may get some sense of the basic processes involved if we think of the computer as a system which is able to perform numerical computation and to follow instructions with extreme rapidity but which is not able to program itself. The numbers and the instructions which form the program the computer is to follow are stored in an essential part of the computer called the memory. A second important portion of the computer is the control whose function it is to interpret orders. The control must convert the order into an appropriate set of voltages to operate switches, etc., and thereby carry out the instructions conveyed by the order. A third basic element of a computer is the arithmetic unit, which contains the circuits which actually perform the arithmetic computations: addition, subtraction, etc., the control and arithmetic components being called the control processor. Finally a computer requires appropriate input — output devices for inserting numbers and orders into the memory and for reading the final result. The input — output components may be punched cards, or paper tape, magnetic tape, photographic film, typewriters, printers, etc.

Suppose we consider an order to perform an addition or division, etc., has been transmitted to the central processor. In response to this order the control must select the correct operands from the memory, it must transmit these operands to the correct arithmetic unit, and it must return to the memory in some previously designated place the result of this computation. The memory serves, then, to store not only the original input data but also the partial resuls which will have to be used again as the computation proceeds. Lastly, if the computation is not to cease with the execution of this instruction and the storage of the partial result, the control unit must automatically sequence to the next instruction. The connection of the control unit back to the input is to permit insertion of more data when room becomes available in the memory.

37. Flip-Flop

The flip-flop is a storage cell with two inputs and two outputs. A pulse applied to the set input flips the circuit to the ONE state; a pulse applied to the rest input flops the circuit to the ZERO state.

A simple triode flip-flop is shown in Fig. 46. At equilibrium one tube is conducting and the other is cut off. If T_1 is nonconducting and T_2 is conducting, a positive pulse applied to the grid of T_1 causes it to conduct. The resultant plate current makes the plate negative. This negative potential when applied to the grid of T_2 causes T_2 to conduct less. As a result the voltage across R_{12} decreases causing the plate of T_2 to become more positive. This positive potential when fed back to the grid of T_1 causes T_1 to conduct more. This process is cumulative until T_1 reaches saturation and T_2 is eut off.

If now a positive pulse is applied to the grid of T_2, T_2 conducts and, as a result, the voltage at the plate becomes more negative; this negative potential fed to the grid of

T_1 causes T_1 to conduct less. This process is cumulative until T_1 is cut off and T_2 reaches saturation.

A positive pulse applied to the grid of T_1 is a set pulse. It places the flip-flop in the ONE state: T_1 conducting and T_2 cut off, the ONE output line being positive and the ZERO output line negative. Fig. 46 shows the flip-flop in the set or ONE state. A positive pulse applied to the grid of T_2 is a reset pulse. It places the flip-flop in the ZERO state: T_2 conducting and T_1 cut off, the ZERO output line positive and the ONE output line negative.

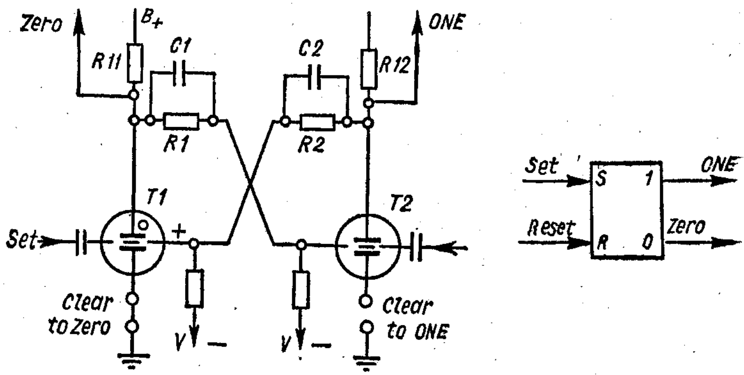

Fig. 46

Negative pulses produce opposite effects from positive pulses. A negative pulse applied to the grid of T_1 resets the flip-flop. A negative pulse applied to the grid of T_2 sets the flip-flop.

The flip-flop may be placed manually in the ZERO state by opening the switch in the cathode of T_1. Since T_1 cannot conduct, T_2 does conduct and the ZERO output line becomes positive. We say that the switch clears the flip-flop to ZERO. Similarly, opening the switch in the cathode of T_2 clears the flip-flop to ONE.

38. Computer Memory

The computer has pervaded most fields of human activity and may well be the most important innovation of our age. Born out of the technology of communication, it is capable of handling enormous amounts of information at tremendous speeds. What makes it so potent is the fact that a single mechanism can perform any information-processing task. The same mechanism can control industrial processes, guide space vehicles or help to teach children. This diversity of tasks is made possible by the simple idea of the stored program.

The trick is to control electronically the nature and sequence of arithmetical and logical processes that are themselves electronic. In other words, what determines whether an addition, multiplication or some other operation is executed, what determines the inputs of the operation and what determines the disposition of the result are not built into the machine but are part of the electronic process itself. A program is the enumeration of theses determining commands; it specifies the method used for the solution of a problem in detail. When the machine is in operation, both the commands and the numbers or symbols being processed are constantly being taken out of and put into a depository of information known as a memory.

The commands, numbers or symbols needed in a processing task — known collectively as words — are stored in the memory, each with a certain «address». The address identifies the stored word and determines a definite physical location within the memory device. The power and universality of programming arise from the capacity to address the memory selectively, that is, to direct a word into any address and to retrieve it in a very short time, regardless of how the address was previously used.

Digital information in a computer is expressed in «bits», each bit being the statement of a single alternative: yes or no, 0 or 1. A group of n bits can code a^n alternatives, which can express 2^n binary numbers. Accordingly all combinations of four 0's or 1's (0000 to 1111) can express 2^4, or 16, numbers, for example the numbers from 0 to 15. A sequence of bits can equally well represent a collection of arbitrary symbols, English words or artificial words.

Part IX

EXERCISES FOR RECAPITULATION

I. **State the forms and functions of the Participles and translate the following sentences:**

1. Having determined the number of amperes and the number of volts, we can find the resistance of the coil by using Ohm's law. 2. Practically all the resistance is in the cell itself, the resistance of the ammeter being too small to be considered. 3. A part of the energy delivered to any motor or generator is lost within the machine itself, being converted into heat and wasted. 4. The fluorescent screen scheme requires that the radio current being investigated is periodic, that is, it repeats its form for several seconds. 5. In mapping a field around a magnet, it must be remembered that the earth's field may exert considerable influence on the compass needle in addition to the effect of the field being studied. 6. Leakage from a magnet is similar to current leakage from an electric circuit having a bare electric conductor immersed in a liquid conducting medium of relatively low conductivity. 7. The conductor being wound into a coil, the fields about each turn combine and create a strong magnetic field about the coil. 8. One may say that the relative motion of both the flux and the conductor determines the e. m. f. induced. 9. Having been carefully tested the device was put into operation. 10. A diode employing a large bias producing resistor yields a current proportional to the peak of the applied voltage over a wide range. 11. The current for nominal voltages is low in such a diode, but a d. c. amplifier overcomes this difficulty, making it possible to use an inexpensive indicating meter. 12. Connected to an ammeter, a thermocouple measures the amount of heat energy falling upon its front face. 13. Light from a carbon arc, having passed as a parallel beam through a glass tube containing sodium vapor, is brought to a focus at the slit. 14. The atom of the metal, having lost electrons, is no longer electrically neutral — it is positive. 15. X-ray pictures are similar to shadows cast by the objects being photographed. 16. Being cold, the cooling unit absorbs heat from the refrigerator and warms up. 17. In a body which is positively charged most of the atoms are neutral, having the proper complement of electrons, others have had one electron removed. 18. A piece of zinc and a piece of copper, when dipped into a dilute sulphuric acid, are capable of producing a continuous electric current. 10. Fur, if rubbed on a dry day, crackles and gives off minute sparks. 20. Any material, like glass which allows light to go through it, so that objects can be distinctly seen, is called tsansparent, water and air being the most common transparent substances. 21. Sound travels at a speed of 1,090 feet per second in air at 0° C, the speed increasing about 2 feet per second for each degree rise in temperature. 22. In any portion of a substance in which the matter

is acted upon by a force tending to move it, there is said to be an electric field. 23. An electric field is also said to exist in any region of free space where a charge, if placed there, would have a force exerted upon it tending to move it. 24. A line of force is usualy a curved line, though in certain special cases it may be straight. 25. A closed circuit may contain several sources of emf.; in this case the resultant emf acting around in the sircuit is the algebraic sum of all these emf's, the latter acting around the circuit in one direction being taken as positive and those acting in the opposite direction being taken as negative. 26. In any electrical conductor or system in which there is a flow of current there is a certain amount of energy continually being lost or converted into forms not readily available for use.

II. State the form and functions of the Gerunds and translate the following sentences:

1. In this case the reading will fall slowly after reaching full load, although the load will be actually constant. 2. Electrostatic voltmeters are useful laboratory standards for checking a. c. instruments against direct current standards. 3. Before switching on current for a test the circuit should be thoroughly checked over to see that it is in accordance with the circuit diagram, particular care being taken that ammeters are not directly across the mains. 4. The action of the triode is most easily explained by noting that the grid, situated in space between the filament and the plate, may assist the space charging in limiting the plate current, or may nullify the space charge effect and thereby increase the plate current according as its potential is negative or positive. 5. If the atom should progress one way or the other, it would result in the copper itself being carried from one end of the wire to the other and then through the battery. 6. On joining the upper ends of the metals with a metal wire we caused the current to flow through the wire. 7. The use of a cooling medium prevents the device from overheating. 8. As radio waves travel away from their point of origin, they become attenuated as a result of spreading out and because of some energy being lost in travel. 9. Laminating the armature iron does not entirely eliminate the eddy-current losses, but it does reduce them to small magnitude. 10. The most common method of magnetizing permanent magnets is to insert the magnets in a suitable exciting coil and to cause a large current to flow in the coil. 11. The new method could be used with great advantage without the machine being overheated. 12. The meter being highly accurate is of the greatest importance for getting the necessary experimental data. 13. We know of silver and copper being very good conductors of electricity. 14. Breaking the circuit causes sparking. 15. Not stopping the machine will prevent too rapid cooling with subsequent freezing of the bearings or warping of the shaft. 16. The dynamomotor is compact, light and highly efficient because of the armature reaction being small. 17. When a bar of iron is thrust into a fire it becomes heated due to the atoms comprising the bar becoming agitated

III. State the forms and functions of Infinitives and translate the following sentences:

1. A radio transmitter is essentially a device for producing radio frequency that is controlled by the intelligence to be transmitted. 2. When a condenser is connected to a source of continuous e. m. f., the condenser takes sufficient charge to bring its plates to a difference of potential equal to the e. m. f. of the source to which it is connected. 3. If a unit north pole is allowed to move freely in a magnetic field,

it will move in the direction of the field at each point. The total field is considered to be made up of a large number of such lines. 4. When the current in a circuit varies Ohm's Law in the form in which it is stated for constant current circuit no longer serves to define a current. 5. A coil to be used at frequencies below 300 k. c. is likely to be somewhat large if wound in a manner that would be entirely appropriate at higher frequencies. 6. Electron emission may be produced by electrons impinging upon substances with sufficient velocity. 7. Strong electric fields acring on gases or vapors may cause the gas particles to collide with sufficient energy to release electrons from the gas. 8. We know water to flow with less resistance in a large pipe than in one of small section. 9. If we double the force pushing the electrons around a circuit, we expect them to move twice as fast, all other things being equal. 10. If the electrodes are assumed to be in a good vacuum then the effects of gas are negligible. 11. To produce currents of the magnitude occurring in everyday experience requires the motion of electrons measured in billions of billions per second. 12. To produce a current of one ampere in a coper wire one millimeter in diameter we need that the average velocity of the electrons be only about·001 cm. per second. 13. Suppose an electron to be in an evacuated vessel in which is also a positively charged metal plate. 14. If there happens to be a second electrode close to the sourse of secondary emission, having a higher positive potential than this source, the secondary emission electrons will tend to flow to this second electrode. 15. An a.-f. amplifier is usually defined as one which is to work in range of frequencies from 20 — to 20,000 cps. 16. In the case of the phototube, the source of energy is a beam of light, feeble as that may seem to be. 17. The only way to stop or control the anode current is to decrease or remove the anode voltage. 18 When the temperature becomes high enough for the atoms to evaporate, the material or solid that they compose rapidly disintegrates. 19. Non-metallic ions, having extra electrons, can be made to give them up and become again atoms of non-metallic elements. 20. The motion of the atoms makes the molecules move, and this motion is heat. 21. The earth is known to contain large iron ore deposits, some of these deposits being almost pure iron. 22. There is a theory that magnetism is due to large electric currents which are known to be flowing around the earth, not only in the earth's crust but also in the air above. These earth currents seem to be connected in some direct way with the earth's rotation. This appears to be corroborated by the fact that the earth is magnetized in a direction almost parallel to the earth's polar axis. 23. Copper is claimed to have a relatively large conductive value.

IV. Find Verbals, state their forms and functions and translate the following sentences:

1. The radio waves produced by an alternating current will vary in intensity with the frequency of the current. 2. Frequencies ranging from 100 to 1500 kc. are referred to as medium radio frequencies. 3. An electron leaving the surface, the metal becomes positively charged. 4. Having studied all the known elements, Marie Sklodowskaya proved uranium and thorium to discharge an electroscope. 5. In accordance with the kinetic theory of matter the electrons within the metal are known to be in a constant state of motion. 6. Graphite is used as a moderator in the atomic pile because of its being cheap and its ability to stand high temperatures. 7. In making permanent steel magnets the result to be obtained is to prepare a quality of steel with

both high retentivity and coercitivity. Such steel is called magnetically hard steel. The steel has to be heated and then quenched to give it mechanical hardness. 8. By attentively considering the physical and chemical chantes that can take place in substances, we have been led to see that these changes involve transformation in something else called energy associated with matter. 9. The unit of work is the work done in moving a body a distance of one centimetre against a force of one dyne acting in that direction. 10. The process of weighing on a balance consists in making a comparison of these bodies as regards equality in mass by testing the equality or inequality of the forces acting on them due to gravity. 11. Imagine a wooden and an iron ring of the same size wound over with the same number of turns of wire, forming a circular solenoid and the same current sent through each wire. There would be then the same magnetizing force in both cases acting on the iron and wooden magnetic circuits. 12. If the unit pole were held at a certain pole it would require a certain mechanical force applied to it to prevent it from moving in the direction of the field. 13. Magnetic flux is considered to be the result or effect due to the action of a magnetic force on a magnetizable body. 14. If a man lifts up a stone, he moves it against the direction in which the force of gravity, if allowed to act, would move it, and he does work against the force of gravity. 15. Drawing the north pole of the magnet or the north pole of the solenoid away from the ring coil creates a clockwise induced secondary current in the ring coil. 16. On stopping the primary current, there is created a transient secondary current in the same direction as the primary one. 17. If there is no iron or magnetic material in or around the coils,then the total magnetic flux passing through the secondary circuit will be proportional to the strength of the primary current, assuming the position of the coil to remain unchanged. 18. The mutual inductance of two coils is said to be one "henry" when the passage of one ampere through one coil causes a total magnetic flux of one weber to be linked with the secondary coil. 19. In any case, the whole area of the hysteresis loop represents the total work done in taking a cubic centimetre of the iron through the magnetic cycle represented by that loop and is generally expressed in ergs. The reader may be assisted to understand the above mentioned statement by considering the analogy between magnetic work and mechanical work. 20. In the construction of an electromagnet, the object, generally speaking is to procure the strongest possible magnegic flux density in the interpolar air gap or gaps, and to obtain this by the least possible excitation of ampere-turns on the magnetizing coils. 21. The total flux across the very narrow air gap separating the attracting poles may be considered to be made up of two parts, one half being as if it were a flux belonging to and coming out of one pole, and the other half being a flux in the same direction, proceeding into and belonging to, the adjacent opposite pole. 22. Moving a north pole towards a coil induces a counter-clockwise current in it. 23. In dealing with the power taken up in alternating current circuits, there are two cases to be considered. 24. There is an absolute rule for fixing the size and length of wire to be employed for the magnetizing coil; it has to be determined by various conditions, such as the electromotive force at disposal for producing the current, and the amount of power which can be dissipated in this coil as heat. 25. Turning to the subject of electromagnetic induction, the student should notice that if a secondary coil is connected to a galvanometer, and if a primary solenoid is brought up towards a secondary coil, the primary coil being traversed by a current, we obtain inductive effects of the same character in the secondary coil that we did when employing a permanent magnet. 26. Similar poles repel, opposite poles attract, understanding by the term similar poles those poles that are found to be magnetically alike, and by opposite poles those that are not like in a magnetic sense when tested against the same poles of a third lodestone.

V. Find predicates in the following sentences and translate the sentences:

1. If there is a break in the circuit, so, that electrons cannot bridge the gap, the circuit is said to be opened. 2. If we short-circuit the cell, that is, connect it to a very low resistance, the current will depend on the e. m. f. of the cell and its internal resistance. 3. The three electrode tubes function because of the effect of the grid in the potential distribution between the filament and the plate. 4. Cooling of most tubes means that the heat liberated at the anode must pass through the vacuum inside the tube. 5. In high-gain audio-frequency amplifiers having a good low-frequency response, regeneration from a common plate impedance often causes the amplifier to oscillate at a frequency of a few cycles per second.

VI. Translate the following sentences, paying attention to the verb-forms in the Passive Voice:

1. When the molecules of even a good insulator are acted upon by an electric field, there is a motion of electrons due to this field. 2. The possibility of a break-down of an insulator which is referred to in the above article is due to high voltage. 3. The exact operation of some devices cannot be much relied upon due to their being slightly influenced by the changes in the ambient temperature. 4. If the electron is allowed to go back to the atom the balance of charge is restored and the atom is again uncharged or neutral. 5. The conclusions which were arrived at by the experimenter fill the demands of the present state of technical development. 6. It should be noted that each control field is given a definite polarity. 7. A piece of apparatus which has the ability to maintain one of its terminals at a higher potential than the other, even though a current is allowed to flow through it, is said to develop an electromotive force. 8. The hindrance to the flow of electrons, known as electrical resistance, may be thought of as similar to mechanical friction. 9. Before studying alternating currents and voltages, consideration should be given to some of the properties of sine curves. 10. When the microphone is being spoken into, the alternator does not produce a high-frequency current of constant amplitude. 11. The resistance of the carbon granules is caused to decrease or to increase by the change of the pressure of the diaphragm. 12. The antenna current represented is referred to as modulated. 13. When the microphone is not acted upon, the diaphragm remains stationary. 14. The inward displacement of the diaphragm is followed by a decrease of the resistance of the microphone. 15. Resistance may be thought of as a measure of the number and violence of the collisions that the free electrons encounter during a certain interval of time. 16. The photoelectric cell, or "electric eye", as it is often referred to, has made possible television and a large number of other processes. 17. Atoms of zinc may be looked upon as composed of electrons' and zinc ions. 18. The metal deposited by the current does not adhere well to the plate of a voltmeter or electrolytic cell, if the action proceeds too rapidly, also errors will arise in the estimation of a current by the

electrolytic method, unless certain precautions be carefully attended to.

VII. State the forms of Subjunctive mood and translate the following sentences:

1. If the electrons acquire enough energy from some outside source (temperature, light, and so on), they will jump to a higher energy level, passing the forbidden gap. 2. If a certain amount of energy were given to an electron in the valence band, the electrons would be freed from the atomic structure of the solid and jump into the conduction band to take part in electric-current flow. 3. Should crystallization take place spontaneously or too quickly, many centers appear from which the process of crystallization develops and a "breaking" surface forms. 4. Were pure germanium doped from both sides with donor and acceptor atoms, a PN junction would be formed where these two layers met. 5. In case the N layer is more heavily doped, the diffusion capacitance is proportional to the total current. 6. Provided a battery were connected to the PN junction, with the plus pole connected to the N layer and the minus pole to the P layer, the voltage drop would appear across the PN junction because both layers are good conductors. 7. If the polarity of the battery be reversed, i. e., plus pole on the P layer and minus pole on the N layer — the potential barrier is lower by the magnitude of the applied battery voltage. 8. To have the transistor in the common emitter configuration it is necessary that the signal-voltage source (should) be moved to the base lead. 9. If the P- and N-type semiconductors had been combined into one crystal free electrons from the N layer would have spread into the P layer, where they would have recombined with free holes. 10. Unless an outside voltage were applied to both sides of the crystal, the potential barrier would not change. 11. Should the characteristics from the first quadrant be enlarged in the vicinity of the vertical axis, we should see that collector current flows even if the collector-to-base voltage is zero. 12. If we were to avoid the use of transformers, we should have to apply feedback to change the values of the input or the output resistance of the transistor. 13. If a voltage be applied between the base and the emitter, the complete voltage drop will apper at the depletion layer and will change the potential barrier. 14. Were the base spreading resistance neglected, we should be able to make the logical conclusion that the transistor-current gain is proportional to the transistor input impedance. 15. If, instead of a resistor, an inductance should be put into the current, L—C coupling is obtained. 16. If the battery could not be tapped at the middle, the loudspeaker could be connected as mentioned above. 17. Provided the portion of the output fed back to the input were of the same phase as the input signal, the signals would combine to give positive feed-back. 18. It is desirable that an excitation voltage of 0.7 volts should be applied to the 1—K ohm input resistance of the first video stage to obtain a signal of 100 volts at the output of the second video stage. 19. Should a portion of the amplified power at the output be fed back to the input, no signal input, power should be needed to sustain oscillations. 20. Were the positive feed-back realized within the amplifying device, its voltage-versus-current characteristic curve would have, in at least one portion, a negative slope. 21. If the imaginary part be equated to 0, the frequency of oscillations is obtained. If the real part is equated to 0, we are given the necessary condition for the existence of oscillations. 22. Were a very high degree of stability to be achieved,

all frequency determining elements could be put into a thermostatically controlled oven. 23. In case the oscillator operates as a class A amplifier, the operating point is established on the straight portion of the characteristic curve. 24. To obtain an equation that contains frequency, transistors parameters, and impedances of the external elements, it is required that the equation of the imaginary part of the determinant should be equated to 0.

VIII. State the different functions of *should* and *would* and translate the following sentences:

1. If it is desired that the inductance should be more or less independent of the current, an air-gap is inserted in the iron core. 2. While experimenting with inflamable substances one must take care lest the temperature should rise too high. 3. If the temperature should fall below the boiling point the boiling would immediately cease. 4. No substance should be considered completely insoluble. 5. It should be noticed that the two electrons which constitute a single bond are in each case contributed by different atoms. 6. The desirable qualities for a direct-reading instrument are that it should be accurate. It is also desirable that the scale divisions should be about equal in the magnitude for equal differences of current or potential at all parts of the scale. 7. It has been assumed so far that the core has been air; the same value of flux would be obtained if the core had been of any substance with the exception of iron and steel. 8. If the circuit possesses no resistance, the back emf would be constant in magnitude and equal to the applied voltage of the battery.

IX. Analyse the tense-forms in the following sentences and translate them into Russian:

1. When the conditions for fusion **have been met,** the energy released appears as intense ultra-violet radiation which heats up the surface of the reactor wall. 2. After it **had been established** that the macroscopic theory in no way contradicts the microscopic theory, the latter **can be used** for all practical purposes. 3. That laboratory **has been working** at the solution of a very important problem for something like 15 years and it **has produced** some outstanding results. 4. The advantages of high-speed computers **are being studied** very thouroughly for their still wider application. 5. The properties of the material under consideration **were being investigated** by a great number of scientists during many years. 6. It was found that a current **would be set up** between a heated filament and a separate electrode, if the electrode were positive with respect to the filament, but not if it were negative. 8. Progress **is being made** with the internal noise of the transistor. 9. When the electron **is travelling** at the speeds usually encountered in electronics, its mass is 9.1×10^{-13} kg. 10. It **has been stated** that the grid-anode capacitance in the tetrode is very small.

SUPPLEMENTARY PART

Some Comments on the Texts

[1] *Foreseeing the great future in store for space flights* . . . — Предвидя великое будущее для космических полетов . . .

[2] . . . *let alone educating* . . . — не говоря уже об образовании . . .

[3] *Incredibly simple as this relationship seems to be* . . . — как бы невероятно простым не казалось это отношение.

[4] *Although first in agreement with Galvani's interpretation* . . . — Хотя он вначале и соглашался с толкованием Гальвани

[5] *Neither was home production of devices for wireless telegraphy organized* . . . — Не было также налажено отечественное производство приборов для беспроволочного телеграфа.

[6] *In the space of a few years* . . . — Через несколько лет . . .

[7] . . . *is advancing with sevenleague strides* . . . — двигается вперед семимильными шагами . . .

[8] *As far back as the early thirties* . . . — еще в начале тридцатых годов . . .

[9] *Many a time* . . . — Много раз . . .

[10] *Yoffe was after problems* . . . — Йоффе занимался проблемами . . .

[11] *The last thing one could call Yoffe was an armchair scientist.* — Менее всего Йоффе можно было назвать кабинетным ученым.

[12] *A new branch of industry — helio engineering — has come into being.* Появилась новая отрасль промышленности — гелио-техника.

[13] *No sooner does this current start* . . . — Однако, как только возникает этот поток . . .

[14] *In so doing* . . . — При этом . . .

[15] *The relative motion of the coil and magnet is what produces the current and it makes no difference whether the coil alone moves* . . . — Именно относительное движение катушки и магнита и создает ток, при этом безразлично, движется ли сам магнит . . .

[16] *The electron appears to have a dual personality* . . . — Оказывается, что электрон обладает двойственной природой.

[17] *This usage is too well established to be readily overcome* . . . — Это настолько прочно вошло в привычку, что от нее нелегко отказаться.

[18] . . . *there is a little, if any, geometric regularity* . . . — . . . тут мало геометрической правильности, если вообще она существует.

[19] . . . *certain caution must be exerted* — . . . следует проявить определенную осторожность.

[20] *If the seed crystal is "necked down" to a small diameter* . . . — Если кристалл для затравки суживается до маленького размера . . .

[21] . . . *which is extremely rare in nature and fails as a semiconductor at temperatures above 100° C* — который чрезвычайно редко встречается в природе и перестает быть полупроводником при температуре выше 100° Цельсия.

[22] *...to keep human armies at bay.* — ... чтобы держать в страхе армии людей.

[23] *...could do without his pet ray...* — ...мог бы обойтись без своего „любимца" луча...

[24] *As far back as the early 50's...* — ...Еще в начале пятидесятых годов...

[25] *To put it another way, the ruby absorbs...* — Иными словами, рубин поглощает...

[26] *As is the case with most new developments...* — Как это и бывает со всем новым...

[27] *One knows to a high degree of certainty...* — Достоверно известно...

[28] *It goes without saying...* — Само собой разумеется...

[29] *It should be kept in mind...* — Следует иметь в виду (помнить)...

[30] *...the program counter is advanced by one.* — ...счетчик команд передвигается на одно деление дальше.

[31] *...it can be tailored to do a specific job...* — ...она может быть сделана так, чтобы выполнять особую работу...

[32] *In a sense it is...the most awesome machine...* — В некотором смысле..., это сложнейшая машина...

[33] *Suffice it to say here...* — Достаточно сказать...

[34] *The machine keeps the operator up to date on events within the computer...* — Эта машина держит оператора в курсе того, что происходит внутри компютера.

[35] *...just as the coil starts to enter the opposite pole area.* — ..., как раз тогда, когда катушка начинает входить в область противоположного полюса.

[36] *...and hence more power to take care of the added load.* — ... а следовательно, и большую мощность для того, чтобы предусмотреть добавочную нагрузку.

[37] *Electrical measuring instruments depend for their action on...* — Работа электроизмерительных приборов зависит от...

[38] *...fall into this class.* — ...принадлежат к этому классу...

[39] *...secondary emission is depended on for a source of electrons.* — ...источником электронов является вторичная эмиссия.

[40] *...because an electron about to leave the metal...* — ..., так как электрон, который близок к тому, чтобы вырваться из металла...

[41] *...as its name implies,...* — ...как указывает название этой элементарной частицы...

[42] *A precaution must be taken...* — ... Нужно...

[43] *The point is that...* — ...Дело в том, что...

[44] *It was not until several years later...* — ...И лишь через несколько лет...

[45] *...for convenience sake it being called anti-neutrino.* — ..., причем для удобства его называют антинейтрино.

[46] *...it is the only accessible source of information as to what is going on in the depth of the Universe.* — ... это единственный доступный источник информации о том, что происходит в недрах Вселенной.

[47] *...lends itself to mass production...* — ... идет в массовое производство...

[48] *Another way of looking at it is that...* — Иной подход к этому заключается в том, что...

[49] *There is another reason for doing this which has nothing to do with secondary emission* . . . — Для этого есть другая причина, которая не имеет ничего общего с вторичной эмиссией...

[50] *Care is also taken in the design* . . . — В конструкции предусмотрено . . .

[51] . . . *one of the more important of them coming into action* . . . — Причем вступает в действие одна из самых важных нелинейностей...

[52] . . . *an equilibrium condition is at length reached* . . . — в конце концов достигается равновесие . . .

[53] . . . *by some means or another* . . . — . . . так или иначе . . .

[54] *Viewed across the two resistances together, however* . . . — Однако, проходя через оба сопротивления вместе . . .

[55] *Is it a data-processing machine which can automatically spew out yards of accurate and complete business reports?* — Вычислительная ли это машина для обработки данных, которая может автоматически выдавать целые ярды точных и вполне деловых отчетов?

WORD COMBINATIONS AND EXPRESSIONS

a good deal of *много, множество*
along with *наряду с*
a number of, a set of, *ряд, несколько*
and such is the case *так это и бывает, так это и есть*
apart from *кроме, не считая, помимо*
as a matter of fact *в действительности, фактически*
as a result *в результате*
as . . . as *так же . . . как*
as compared to *по сравнению с*
as far as ... is concerned *что касается*
as follows *следующим образом, как ниже следует*
as for *что касается*
as if *как если бы, как будто бы*
as mentioned above *как выше упоминалось*
as regards *что касается, в отношении*
as soon as *как только*
as such *как таковой*
as the case may be *смотря по обстоятельствам*
as the name implies *как указывает само название*
as though *как будто, как если бы, словно*
as to *что касается*
as well *также*
aside from *помимо, за исключением*
at all *вообще*
at any rate *во всяком случае, по крайней мере*
at first *сначала*
at hand *рассматриваемый*
at last *наконец*
at least *по крайней мере*
at once *немедленно, сразу*
at the expence of *за счет*
at times *иногда, временами*
at will *по желанию*
back and forth *назад и вперед*
bear in mind *иметь в виду, помнить*
because of *благодаря, из-за, вследствие*
both . . . and *и . . . и, как . . . так и*
by all means *непременно*
by any means *каким бы то ни было образом, любым способом*
by chance *случайно*
by far *гораздо, значительно, намного*
by means of *посредством, при помощи*
by right *по праву*
by virtue of *благодаря, ввиду, вследствие*
care must be taken *следует принять меры*
close at hand *совсем близко, рядом*
compared to (with) *по сравнению с*
contrary to *в противоположность, вопреки*
deal with *рассматривать, иметь дело с*
depending on *в зависимости от*
despite of *вопреки, несмотря на*
do one's best *делать все возможное*
do without *обходиться без*
due to *вследствие, из-за*
either . . . or *или . . . или*
except for *за исключением*
far from *далеко от*
first of all *прежде всего*
for example, for instance *например*
for the first time *в первый раз, впервые*

for the most part *большей частью, главным образом*
for the purpose of *в целях, с целью*
for the reason *по причине*
for the sake of *ради*
if any, if at all *если вообще, если только таковые имеются*
if it were not for *если бы не*
in accordance with *в соответствии с, согласно*
in addition to *вдобавок, кроме того, к тому же*
in all respects *во всех отношениях*
in any case *во всяком случае*
in any event *при всех условиях*
in case *в случае, если*
in comparison with *по сравнению с*
in contrast *в противоположность*
in effect *в действительности, в самом деле*
in fact *в действительности, в самом деле*
in front of *перед, напротив*
in general *вообще, в общем*
in its turn *в свою очередь*
in like manner *аналогично, подобным образом*
in no way *никоим образом*
in order that, in order to *для того, чтобы*
in part *частично, отчасти*
in particular *в особенности*
in question *о котором идет речь, рассматриваемый*
in so far as *постольку, поскольку*
in spite of *несмотря на*
in the course of *в течение*
in the first place *во-первых, прежде всего*
in this manner *таким образом, таким способом*
in this respect *в этом отношении*
in turn *в свою очередь, поочередно*
in view *ввиду*
instead of *вместо (того, чтобы)*
irrespective of *независимо от*
it goes without saying *само собой разумеется, ясно, очевидно*
keep in mind *иметь в виду*
least of all *меньше всего*
lots of *много, масса*
make use of *использовать*
meet the requirement *удовлетворять требованиям*
moreover *кроме того, сверх того*
much in the same way *почти то же*
neither ... nor *ни ... ни*
no longer *больше не*
no matter *безразлично, неважно, независимо от*
no wonder *неудивительно*
not at all *вовсе не, нисколько*
of course *конечно*
on account of *вследствие, из-за*
on the contrary *наоборот*
on the one hand *с одной стороны*
on the other hand *с другой стороны*
on the part of *со стороны*
on this account *ввиду этого*
once more *еще раз*
other than *кроме*
over and above *кроме этого, вдобавок*
owing to *благодаря, вследствие*
per cent *процент*
play a part *играть роль*
provide for *предусматривать*
provided, providing that *при условии, что; если только*
rather than *скорее чем; а не; лучше чем*
regardless *не считаясь, не взирая на*
result from *получается в результате; происходить от*
result in *давать, в результате, приводить к*
side by side *рядом, бок о бок*
so as to *так чтобы*
so far *до сих пор*
so far as ... is concerned *что касается*
such as *как, например*
take advantage of *воспользоваться*
take care of *заботиться, принимать меры*
take into account *принимать в расчет*
take into consideration *принимать во внимание*
take part *принимать участие, участвовать*
take place *происходить, иметь место*
thanks to *благодаря*
that is *то есть*

that is to say *то есть, иными словами*
that is why *вот почему*
the fact is *дело в том, что*
the former *первый (из упомянутых)*
the point is, the thing is *дело в том, что*
there is every reason to believe *имеются все основания полагать*
this time *на этот раз*
to some extent *до некоторой степени*
twice as much *в два раза больше*
under any conditions *при любых условиях*
under consideration *рассматриваемый, данный*
unless otherwise stated *если нет особой оговорки*
up to *до, вплоть до*
up to now *до настоящего времени*
vice versa *наоборот*
whether *будь-то . . . или; независимо от того . . . или*
with regard to *по отношению к, относительно*
with respect to *по отношению к, в отношении*

Reading Numerals

$^1/_2$ — one half
$1^1/_2$ — one and a half
$^1/_3$ — one third
$^1/_4$ — one fourth
$^1/_5$ — one fifth
$^1/_{27}$ — one twenty seventh
$^1/_{128}$ — one one hundred and twenty eighth
$^7/_9$ — seven ninth
0.5 — zero (o, nought) point five
0.03 — zero (o, nought) point zero three
2.4 — two point four
4.36 — four point three six

Reading Mathematical Signs (Terms)

$+$ plus
$-$ minus
$\times$ multiplied by (times)
: divided by (over)
() round brackets
[] square brackets
$=$ equals (is equal to)
$>$ greater than
$<$ less than
: the ratio of. . . to. . .
2^2 two square (squared)
3^3 three cube (cubed)
4^5 four to the fifth power (the fifth power of four)
10^{-19} — ten to the minus nineteenth (power)
$\sqrt{25}$ the square root of twenty five
$\sqrt[3]{27}$ the cube root of twenty seven
$\sqrt[5]{x}$ the fifth root of x
x' x prime
x'' x double prime
x_1 x sub one
x_2 x sub two

Abbreviations

a. c. alternating current
a. f. audio frequency
bev. billion electron-volt
cgs centimeter — gram — second system
cm (s) centimeter (s)
c. p. s. (c/s) cycles per second
db decibel
d. c. direct current
e. g. for example
e. m. f., emf electromotive force
etc. and so on

e. v. electron-volt
h. p. horsepower
hr (s) hour (s)
i. e. that is
i. f. intermediate frequency
kc. kilocycle
km (s) kilometer(s)
lb (s) pound (s)
mc megacycle
mm (s) millimeter (s)
n — p — n negative — positive — negative
1 ft. one foot
p. h. per hour
p. m. per minute
p — n — p positive — negative — positive
p. s. per second
r. f. radio frequency
rms root mean square
rpm revolutions per minute
70F seventy degrees Fahrenheit
sq square
t. r. f. tuned radio frequency
2 ft. two feet
vs versus
viz. namely
0° C zero degrees Centigrade

List of Symbols

A — Amplification
B — Frequency range, bandwidth
B — Flux density
C — Capacitance
D — Distance
E — Electromotive force
E — Electric field strength
F — Factor
G — Conductance
I — Electric current
I_a — Anode current
If — Component of current at frequency *f*
I_g — Grid current
I_k — Cathode current
I_s — Signal current
I_{sg} — Screen-grid current
L — Inductance
L — Loss
M — Mass of molecule
N — Number
N — Noise factor
R — Resistance
R — Gas constant
T — Temperature
T — Transit time
V_s — Signal voltage
W — Energy
Y — Admittance
Z — Impedance
f — Frequency
f_c — Carrier frequency
f_m — Modulation frequency
l — Length
m — Mass

Abbreviations of Units

A — Ampere
Å — Angström unit = 10^{-10} m
F — Farad
H — Henry
M — Mega = 10^6 (prefix)
V — Volt
W — Watt
Ω — Ohm
c — Cycle
° K — degree Kelvin

VOCABULARY

A

abacus *n* абак, счеты
accelerate *v* ускорять
acceptable *a* приемлемый
accept *v* принимать, допускать
acceptor *n* акцептор
access *n* доступ
accessible *a* доступный, достижимый
accompany *v* сопровождать, сопутствовать
account *v* объяснять, пояснять
to take into account принимать во внимание; **on account of** из-за, вследствие; **on no account** ни в коем случае
accurate *a* точный
acquire *v* приобретать
act *v* действовать на (*upon*)
activate *v* активировать
actuate *v* воздействовать, возбуждать
add *v* прибавлять, суммировать
added *n* слагаемое
adder *n* сумматор, суммирующее устройство
additive *n* добавка; *a* аддитивный
additive method аддитивный метод
address selector адресный селектор
adjacent *a* смежный, примыкающий, соседний
adjust *v* регулировать, приспособлять
adjustment *n* регулирование
adopt *v* принимать
advantage *n* преимущество, выгода
advantageous *a* выгодный, полезный
affect *v* влиять, действовать
age *v* стареть; *n* возраст
agency *n* действие, средство, фактор
agitation *n* колебание, перемешивание
air core воздушный сердечник (без сердечника)
align *v* выравнивать, регулировать
alignment *n* выравнивание, выверка, настройка, регулировка
alkali *n* щелочь
alloy *n* сплав, примесь; *v* сплавлять (металлы)
alternating переменный, синусоидальный (*о токе*)
alter *v* изменять (-ся), менять (-ся)
altimeter *n* альтиметр, высотомер
amber *n* янтарь
amperage *n* сила тока (в амперах)
amper turn ампервиток
ample *a* достаточный
amplification *n* усиление
amplifier *n* усилитель
analogue *n* аналог, модель
analogue-to-digital converter аналого-цифровой преобразователь
angle *n* угол
angular *a* угловой
antimony *n* сурьма
apart *adv* на расстоянии
aperture *n* отверстие, апертура
apparent *a* очевидный, видимый
apparently *adv* очевидно, по-видимому

apply *v* применять, прилагать, прикладывать
appreciable *a* значительный, заметный
approximately *adv* приблизительно
arbitrarily *adv* произвольно
arc *n* дуга; *v* изгибаться дугой
area *n* площадь, область, пространство
arise (arose, arisen) *v* возникать, являться результатом (*from*)
armature *n* якорь (магнита или машины)
arrange *v* устраивать, располагать, классифицировать
arrangement *n* устройство, расположение, классификация
arsenic *n* мышьяк
artificial *a* искусственный
assembly *n* блок, узел
assume *v* допускать, предполагать, принимать за
attach *v* прикреплять, приспосабливать
attachment *n* приспособление
attain *v* достигать
attenuation *n* затухание, уменьшение
attract *v* притягивать
attribute *v* относить к чему-л.; приписывать
audio frequency output voltage выходное напряжение звуковой частоты
augend *n* первое слагаемое
automate *v* автоматизировать
automaton *n* *киб.* автомат
available *a* наличный, доступный
axis (*pl.* **axes**) *n* ось

B

baffle *n* перегородка, экран, щит, отражательная доска
balance *v* уравновешивать
band *n* полоса частот, полоса пропускания
bandwidth *n* ширина полосы
bar magnet полосовой магнит
bead *n* бусинка
beam *n* луч
bearing *n* подшипник
behave *v* вести себя; **behaviour** *n* поведение, режим
bias *v* смещать; *n* смещение
bilateral *a* двусторонний
binary system бинарная система
bit *n* двоичный знак, двоичный разряд
bit storage запоминающее устройство двоичного разряда
bottom *n* дно, низ
boundary *n* граница, край
brain *n* мозг
branch instruction *n* команда ответвления
brake *n* тормоз
break-down *n* *эл.* пробой
break loose *v* отрываться
break through прорываться сквозь
bridge *n* мост; *v* перекрывать, шунтировать
broadcast *v* передавать по радио, вести радиопередачу; *n* вещание
brush *n* щетка
bulb *n* колба
buffer *n* буферная система, буфер
build-up *v* нарастать, наращивать
bulk storage массивное запоминающее устройство
button *n* кнопка
by-pass *n* шунт, байпас; *v* шунтировать, обходить

C

calculus *n* исчисление
cam *n* кулачок, палец
camera tube передающая телевизионная трубка
cancel *v* стирать изображение, вычеркивать, аннулировать
capacitance *n* емкость, емкостное сопротивление
capacitor *n* конденсатор, емкость
capacity *n* емкость, номинальная мощность, способность, производительность, выход
capacity reactance емкостное сопротивление

carbon-granule type тип угольного порошка
care *n* забота, уход; *v* заботиться *(for, about)*
carrier *n* несущий *(о токе, частоте)*, носитель
carrier frequency несущая частота
carrier voltage напряжение несущей
carry *v* нести, носить, проводить
cathode follower катодный повторитель
cathode ray tube (c. r. t.) катодно-лучевая лампа
cause *v* вызывать, заставлять, причинять; *n* причина, основание, дело
cavity *n* резонатор, объемный резонатор, полость
cease *v* прекращает(ся), переставать, приостанавливать
cell *n* элемент
centigrade scale стоградусная шкала
character *n* знак, символ, цифра
charge *v* заряжать; *n* заряд
check *n* проверка, контроль; *v* проверять, контролировать
circuit *n* цепь, контур
circular *a* круглый, круговой
circuit breaker автоматический выключатель, прерыватель цепи
clicking *n* незначительное потрескивание
cling *v* цепляться, прилипать
coarse-mesh grid сетка с крупными ячейками
coat *n* покрытие; *v* покрывать
clock pulse синхронизирующий импульс
code *n* код; *v* кодировать
coherence *n* когерентность; взаимосвязанность
coherent *a* когерентный, последовательный
coil *n* катушка
collision *n* соударение, столкновение
command portion узел управления
communicate *v* сообщать, общаться
communication *n* связь, сообщение
commutator *n эл.* коллектор, коммутатор, преобразователь тока
compound *n* соединение
concave *a* вогнутый
conduct *v* проводить
conductivity *n* удельная проводимость; электропроводимость
conductor *n* проводник, провод
conserve *v* сохранять
constant *a* постоянный; *n физ.-мат.* постоянная величина
constituent *n* составная часть
constitute *v* составлять
continual *a* беспрерывный
continuous *a* постоянный *(о токе)*, непрерывный
contract *v* сокращать, -ся, сжимать, -ся
control *v* управлять, регулировать; *n* регулирование, управление, контроль
control grid управляющая сетка, управляющий электрод
control unit блок управления
conventional *a* обычный, стандартный, условный; общепринятый
converge *v* сходиться, сливаться
conversion *n* преобразование, превращение
convert *v* преобразовывать, превращать
convey *v* передавать; *эл.* проводить
core *n* сердечник, память, запоминающее устройство
counter *n* счетчик, пересчетное устройство, схема
counter-clockwise *adv* против (движения) часовой стрелки
couple *n* пара
coupling *n* связь
cover *v* охватывать, покрывать
cross section поперечное сечение
crucible *n* тигель
cumulative *a* совокупный
curve *n* кривая (линия)

curvature *n* кривизна
cut *v* резать, отключать
cut-off *n* отсечка

D

damage *v* повреждать, портить; *n* повреждение, вред
damp *a* сырой, влажный; *v* заглушать (звук), демпфировать
data *n* данные, информация
date *n* дата, период, продолжительность
deficiency *n* нехватка, недостаток
deflect *v* отклонять
density *n* плотность
deplete *v* уменьшать, истощать
depletion *n* обеднение; истощение (электронами)
depress *v* подавлять; ослаблять
derange *v* выпадать из синхронизма, расстраивать
design *v* проектировать, конструировать; *n* проект, конструкция, расчет
desk calculator настольная (малогабаритная) счетная машина
detect *v* обнаруживать, детектировать
detection *n* обнаруживание, детектирование
device *n* устройство, схема, прибор
develop *v* проявлять, разрабатывать, развивать
dial *n* циферблат, шкала, лимб
differ *v* различаться, отличаться
difference *n* разница, различие
diffuse *v* дифундировать, рассеивать
diffused base диффузионная база
difraction *n* дифракция
digit *n* разряд (числа), цифра, знак, символ
digital computer цифровая счетная машина
dim *a* тусклый, неясный
dimension *n* размер, измерение
direct current (d. c.) постоянный ток
directly *adv* прямо, непосредственно
disadvantage *n* недостаток, ущерб, неудобство, невыгодное положение
disc cathode *n* дисковый катод
discharge *n* разряд; *v* разряжать
discrete *a* дискретный
discriminate *v* различать, распознавать, выделять
disintegrate *v* распадаться, разрушаться
disintegration *n* распад, разрушение
dislodge *v* выбивать, смещать
displace *v* смещать, перемещать
dissimillar *a* разнородный, несходный
dissipate *v* рассеиваться
dissociate *v* распадаться
distant *a* отдаленный, дальний, далекий
distinction *a* различие, отличие
distinct *a* отчетливый, ясный, определенный
distinguish *v* различать, отмечать
distort *v* искажать, искривлять
distortion *n* искажение
distribute *v* распределять
disturb *v* нарушать, мешать
divide *v* делить(ся), разделять(ся)
divider *n* делитель, делительное устройство
domain *n* домéн, сфера, область
donate *v* служить донором (в полупроводниках)
donor level донорный уровень
dot *n* точка
dotted line пунктирная линия
double *v* удваивать
drift *v* отклоняться, сдвигаться; *n* сдвиг, уход
drive *v* двигать, приводить в движение; *n* передача, привод
driver stage задающее устройство, задающий каскад
drop *n* капля; перепад; *v* капать, падать, спадать
dual *a* двойной, двойственный
due *a* надлежащий, должный

dull *a* тусклый
duration *n* длительность
dyne *n* дина *(ед. длины)*

E

eddy *n* завихрение
eddy currents токи Фуко, вихревые токи
effect *n* действие, влияние; *v* совершать, осуществлять, выполнять
effective value эффективное значение
effort *n* усилие
elapse *v* проходить *(о времени)*
electrify *v* электризовать, электрифицировать
e. m. f.— electro-motive force электродвижущая сила
electron-pair covalent bond ковалентная связь электронной пары
electro-plating *n* гальванопокрытие
electrostatic электростатический
elements *n* стихия
elevation *n* возвышение, поднятие
eliminate *v* устранять, уничтожать
elongate *v* растягивать (-ся), удлинять (-ся)
emergency *n* авария, непредвиденный случай
emission *n* выделение, излучение, эмиссия электронов
emit *v* испускать, излучать, выделять
enclose *v* окружать, охватывать
encode *v* кодировать, шифровать
energize *v* возбуждать, пропускать ток
energy band энергетическая зона
engage *v* нанимать; *тех.* зацеплять
enhanced emission повышенная эмиссия катода
environment *n* окружающая среда
equidistant *a* эквидистантный, равноудаленный
equilibrium *v* равновесие
erasability *n* способность стирать
erasable *a* стираемый
escape *v* выделяться, уходить (о газах, паре); *n* утечка, выпуск
essential *a* существенный, необходимый
evacuate *v* выкачивать, высасывать, разрежать воздух
even *a* четный, ровный; *adv* даже, ровно
evidence *n* очевидность, доказательство, данные
evolve *v* развивать (-ся), выделять (-ся)
exceed *v* превышать, превосходить
excess *n* избыток, излишек
excessive *a* чрезмерный
excitation *n* возбуждение
excite *v* возбуждать, возбудить (ток);
execute *v* выполнять
exertion *n* усилие, напряжение
exhaust *v* разрежать, выкачивать, исчерпывать
exhibit *v* проявлять, обнаруживать
expand *v* расширять (-ся), увеличивать (-ся)
expose *n* подвергать действию
exposure *n* выдержка, экспозиция
external *a* наружный, внешний

F

facilitate *v* облегчать, продвигать
fading *n* затухание, фединг
fail *v* неудаваться, отказаться действовать
failure *n* авария, провал
feed (fed, fed) *v* подавать, питать; *n* подача, питание
feedback *n* обратная связь, регенерация
fibrous *a* волокнистый
fidelity *n* точность воспроизведения
field-effect transistor транзистор с управлением поля, канальный триод

file *n* массив, картотека, комплект
field intensity напряженность поля
field winding обмотка возбуждения
filament *n* нить накала, волосок
film *n* плёнка, оболочка
fin *n* ребро
finite *a* конечный
fit *v* пригонять, снабжать
fix *v* прикреплять
fixed *a* постоянный, неподвижный, прикрепленный
fixed storage закрепленное (постоянное) запоминающее устройство
flashlight *n* электрический фонарь
flashover *n* короткое замыкание между щетками, перекрытие изолятора дугой
flash tube лампа, вспышка; импульсная лампа
flat-top antenna плоская антенна
flexibility *n* гибкость
flip *v* перебрасывать(ся)
flip-flop circuit цепь мультивибратора, цепь ждущего мультивибратора
fluctuation *n* флуктуация, случайное колебание или отклонение
flux *n* поток
flux density магнитная индукция
foil *n* фольга
forbidden band запрещенная энергетическая зона
forbidden gap запретная зона
force *n* сила; *v* заставлять, принуждать, форсировать
forward *adv* вперед
frame *n* рама, станина, кадр, поле
framework *n* корпус, рама, каркас
frequency *n* частота
frequantly *adv* часто
friction *n* трение
full-wave type rectifier двухполупериодный выпрямитель
functional unit функциональное устройство
fundamental *a* основной, существенный
fission *n* деление, расщепление
fusion *n* плавление; *яд. физ.* синтез, слияние

G

gain *v* усиливать, приобретать
gap *n* зазор, промежуток, разрядник
gate valve стробирующая лампа
gear *n* зубчатая передача; *v* зацеплять(ся)
general-purpose computer универсальная (общего назначения) вычислительная машина
generate *v* генерировать, вырабатывать, производить
germanium *n* германий
give off *v* выделять
give rise *v* вызывать, приводить (к ч.-либо)
glow *v* сверкать, накаляться докрасна, добела; светиться
glow-lamp *n* лампа накаливания, лампа тлеющего разряда
grid *n* сетка
grid anode capacitance емкость сетка — анод
grid bias сеточное смещение
grill *n* решетка
ground *n* земля, заземление; *v* заземлять
grounded-cathode circuit схема с общим (заземленным) катодом
grounded-grid circuit схема с общей (заземленной) сеткой
grown-junction *n* выращенный переход

H

hairspring *n* волосковая пружина
half-sine wave *n* полусинусоидальная кривая
half-wave rectifier полупериодный выпрямитель

handle *v* управлять, обращаться с, доставлять, осуществлять
hardware *n* оснастка, аппаратура, схемная часть
headset *n* головной телефон
heat *n* теплота, накал, нагрев; *v* нагревать (-ся)
heavily doped сильно легированный
helium *n* гелий
hitherto *adv* до сих пор, прежде
hole *n* дыра, отверстие, дырка
horsepower *n* лошадиная сила, мощность *(в лошадиных силах)*
hydrogen *n* водород
hysteresis *n эл.* гистерезис, отставание фаз

I

identical *a* равный, тождественный
ignite *v* зажигать (ся), загораться
ignition *n* зажигание, вспышка; воспламенение
image *n* изображение, *v* изображать, давать изображение
image orthicon ортикон с переносом изображения
impact *n* удар, импульс, толчок
impact strength сопротивление удару
impedance *n* полное сопротивление, импеданс
impede *v* препятствовать, задерживать, мешать
imperfection *n* дефект кристалла (кристаллических решеток)
impinge *v* ударяться, падать
impregnate *v* пронизывать, насыщать
impress *v* приложить, прикладывать
impurity *n* примесь, засорение
incandescence *n* накал, каление
incandescent *a* раскаленная, накаленная добела
incandescent lamp лампочка накаливания
inch *n* дюйм
induce *v* индуктировать, наводить
induction *n* индукция, наведение
infer *v* заключать, выводить; предполагать, подразумевать
ingot *n* слиток
inherent *a* присущий, свойственный
inject *v* вводить, впускать, вбрызгивать
input *a* вход
input unit *n* входной блок (устройство)
insert *v* вставлять; *эл.* включать
instruction word команда, командное слово
insulate *v* изолировать
integer *n* нечто целое; *мат.* целое число
integrator *n* интегрирующее устройство, интегратор
intelligence *n* информация, сведения, программа
intensity *n* напряженность
interchangeability *n* взаимозаменяемость, заменяемость
interdependence взаимосвязь, взаимозависимость
interface *n* граница, контактная поверхность
interfere *v* вмешиваться, мешать, служить препятствием
interference *n* помехи
interlacing *n* сплетение, переплетение
intermediate *a* промежуточный
interpose *v* вставлять, вводить между
intrinsic *a* внутренний, присущий, естественный
intrinsic semiconductor беспримесный, чистый полупроводник
involved *a* данный, сложный
irradiation *n* иррадиация, излучение
irrespective *adv* независимо, безотносительно
iteration *n* итерация, повторение

J

jar *v* вибрировать, дребезжать; *n* конденсатор, банка
jewel *n* драгоценный камень
jumble *v* смешивать, спутывать
junction transistor контактный транзистор, пластинчатый транзистор

K

keyboard *n* коммутационная модель, клавиатура
knock loose *v* выбивать

L

lack *v* нехватать, недоставать; *n* недостаток, нехватка
laminated *a* слоистый, пластинчатый
lattice *n* решетка
layer *n* слой, пласт; **heaviside layer** слой хевисайда
lead *n* провод, ввод; свинец, свинцовый аккумулятор
leak *v* течь, просачиваться
leakage *n* утечка, рассеяние
leg *n* ножка, подпорка, стойка
lengthwise *adv* в длину, вдоль
lens *n* линза, объектив
level *n* уровень
level logic system потенциальная логическая система
lightweight *n* спорт, легкий вес
likely *adv* вероятно
likewise *adv* точно так же, подобно
limb *n* лимб, деталь; сердечник электромагнита
linear *a* линейный
link *v* соединять; *n* связь, соединение, звено
linkage *n* потокосцепление, полный поток индукции
lint *n* корпия
liquid *a* жидкий; *n* жидкость
load resistance нагрузочное сопротивление
locate *v* располагать
logic gate *n* логический вентиль
longitudinal *a* продольный
loop *n* петля, отверстие, контур, виток, пучность (волны)
loop antenna рамочная антенна
lose (lost) *v* терять, ослаблять
loose *a* свободный, просторный, неточный
loss *n* потеря
loudspeaker *n* громкоговоритель, репродуктор
luminous *a* светящийся, светлый

M

magnetic flux магнитная индукция
magneto-motive магнитодвижущийся; **m. m. f.— magneto-motive force**
majority carrier основной носитель заряда
make use of использовать
malfunction *n* неправильная работа, аварийный режим
man-made *a* искусственный
manual *a* ручной, с ручным управлением
mark *v* отмечать, обозначать
match *v* согласовывать, приравнивать
matter *n* вещество, материал
medium *n* среда; *a* средний, умеренный
melt *n* плавление; *v* плавиться
melting point *n* точка плавления
memory *n* память, запоминающее устройство
memory unit блок памяти, запоминающее устройство
mercury *n* ртуть
merge *v* поглощать, сливаться
mesh *n* сетка, отверстие
meter *n* счетчик, измерительный прибор
mica *n* слюда
microwaves *n* микроволны, сантиметровые волны
mil *n* одна тысячная дюйма
minority carrier неосновной носитель заряда
misalighnment *n* ошибочное направление, несовпадение

missile *n* снаряд, управляемый снаряд
mixture *n* смесь
mobility *n* подвижность, мобильность, возбудимость
moisture *n* влага, влажность
mold *v* отливать в форму, формовать
monitor *v* контролировать, проверять; анализировать; *n* монитор, контролирующий прибор, прибор для управления
moreover *adv* сверх того, кроме того
mosaic *n* светочувствительная мозаика, мозаичный фотокатод
motion *n* движение, ход
movable *a* передвижной, подвижный
moving coil instrument магнитоэлектрический прибор
moving picture кинофильм, движущаяся картина
multiply *v* умножать
multiplier *a* умножитель, множительное устройство
muon-mu meson мю мезон
mutual *a* взаимный
mutual conductance взаимоиндукция
mutual inductance крутизна характеристики электронной лампы

N

natural frequency собственная частота
negative *a* отрицательный
neglect *v* пренебрегать
negligible *a* незначительный
necessitate *v* делать необходимым
needle *n* игла, стрелка (прибора)
net *a* чистый
net charge полный, общий, результирующий заряд
network *n* сеть, четырехполюсник (радио)
neutralize *v* нейтрализовать
neutrino *n* нейтрино
nitrogen *n* азот
noise factor коэффициент шума, шумовой фактор
non-uniform *a* неравномерный
notice *v* замечать, отмечать
noticeable *a* заметный, значительный
nuclear engineering ядерная техника
nucleus (*pl.* **nuclei**) *n* ядро

O

obliteration *n* уничтожение, стирание
obtain *v* получать, добывать
obvious *a* очевидный, явный
odd *a* нечетный
offer resistance оказывать сопротивление
offset *n* смещение; *v* компенсировать
once *adv* раз
opaque *a* непрозрачный, непроницаемый
operand *n* операнд, компонент операции
oppose *v* оказывать сопротивление, сопротивляться
opposite *a* обратный, противоположный
opposition *n* сдвиг фаз, противодействие
order *n* команда, порядок, разряд (числа)
origin *n* возникновение, начало, источник происхождения
oscillator *a* генератор, гитеродин, осциллятор
oscillate *v* колебаться, вибрировать
otherwise *adv* иначе, в противном случае
outer *a* внешний, наружный
output *n* выход, производство, производительность
output auxiliaries выходное устройство
outset *n* начало
oven *n* печь, термостат
overlap *v* перекрывать, заходить один на другой
override *n* перерегулирование
oxide *n* окись, окисел
oxygen *n* кислород

P

paper reader считывающее устройство
paramagnetic *a* парамагнитный
partial *a* частичный, неполный
particular *a* особый, данный
pass *v* пропускать, передавать (ток через цепь)
passage *n* прохождение, проход, канал
pattern *n* растр, рисунок, модель, образец, характеристика, кристаллическая решетка
pendulum *n* маятник
penetrate *v* проникать, проходить сквозь
penetration radiation проникающая радиация
pentavalent *a* пятиатомный, пятивалентный
pentode *n* пентод
perform *v* выполнять, совершать
performance *n* характеристика, работа
peripheral equipment внешнее устройство, внешнее оборудование
permeability *n* проницаемость
persistence of vision инерционность зрительного восприятия
phenomenon (*pl.* **phenomena**) *n* явление
photocell *n* фотоэлемент
pick up *v* улавливать; *n* микрофон, адаптер
pick-up tube телевизионная передающая лампа
picture frame кадр изображения
piece *n* кусок, штука, часть, участок
pile *n* куча, груда; *эл.* батарея
pin *n* штырь, вывод, палец
pitchblende *мин.* уранит, урановая смолка
pivot *v* вращаться, вертеться; *n* точка опоры, стержень
plate *n* анод, пластина, полоса; *v* осаждать, выделять, откладывать
plug-in package сменный блок, штепсель, контактный штырек
plunge *v* погружать
point *n* точка, пункт, вопрос, дело; острие, наконечник; *v* показывать, указывать, заострить, наточить
pointer *n* стрелка прибора
polarity *n* полярность
pole *n* полюс, столб
pole face лицевая поверхность полюса
pole piece полюсный наконечник
poor *a* плохой, бедный
positive *a* положительный
potential difference разность потенциала
power *n* мощность, энергия, степень
pour out *v* изливать, выделять
power supply system система питания мощностью
preaging *n* искусственное старение
precaution *n* предосторожность
predict *v* предсказывать
primary *a* первичный, основной
print *n* шрифт; *v* печатать
printer *n* печатающее устройство
problem set-up *n* схема (макет), проблема, задача, задание
procedure *n* методика, техника, прием
proceed *v* приступать, переходить (к ч.-либо)
process *n* процесс; *v* обрабатывать
processor *n* вычислительная машина для обработки данных
produce *v* вырабатывать, производить, вызывать
product *n* продукт, результат; *мат.* произведение
programme counter счетчик команд
prohibit *v* запрещать
project *v* выдаваться, выступать, проектировать
proof *n* доказательство
propagation *n* распространение
proper *a* надлежащий, должный, правильный, подходящий; собственно

proposition *n* теорема, предложение
prove *n* доказывать, оказываться
provide *v* обеспечивать, снабжать *(with);* предусматривать
provided *cj.* при условии, если только
provision *n* обеспечение
proximity *n* близость
pull *v* тащить, тянуть, выдергивать
pulse train серия импульсов
punch *v* перфорировать, пробивать отверстия
punch-card reader устройство для считывания перфокарт
punched-card-to-magnetic-tape converter *n* устройство, перепечатывающее с перфокарты на магнитную ленту
punched-paper-tape *n* перфорированная бумажная лента
purify *v* очищать
push-pull amplifier двухтактный усилитель

Q

quantity *n* количество, величина
quantitative *a* количественный
quantize *v* квантовать
quench *v* гасить, подавлять
quotient *n* частное, коэффициент

R

radar *n* радар, радиолокатор
radio frequency радиочастота
range *n* дальность передачи
range-finder *n* дальномер
rate *n* скорость, темп, номинал
rating *n* характеристика, номинальное значение, номинальная мощность
ratio *n мат.* отношение, коэффициент, пропорция, коэффициент трансформации
ray *n* луч
read *v* считывать
read circuit схема считывания, цепь считывания
read in *v* записывать
read out *v* считывание данных, выбор (информации)
reader *n* считывающее устройство
readily *adv* легко
reason *n* причина
for this reason по этой причине
reasonable *a* приемлемый, умеренный, разумный, целесообразный
receive *v* принимать, получать
receiver *n* приемник
receptacle *n* гнездо, штепсельная розетка, приемник
reception *n* прием
reciprocal *a* взаимный, эквивалентный; *n мат.* обратная дробь
record *v* записывать; *n* запись
recorder *n* записывающее устройство; регистрирующее устройство
rectifier *n* выпрямитель, детектор
rectify *v* выпрямлять
recurrence *n* возвращение, повторение
reduce *v* понижать, ослаблять, уменьшать, приводить (к), восстанавливать
reduction *n* снижение, уменьшение, сокращение
refer *v* иметь отношение
to be referred (to) ссылаться на, называться
reference *n* ссылка, эталон
reference generator опорный или эталонный генератор
reference voltage опорное, эталонное напряжение
reflect *v* отражать
regard *v* смотреть на что-л.; считаться с чем-л.; рассматривать, считать
refract *v* преломлять
refrigeration *n* охлаждение, замораживание
register *n* регистр, регистрировать
relationship *n* отношение, соотношение
relay *n* реле; *v* передавать
release *v* освобождать, отпускать
reliability *n* надежность

reluctance *n* магнитное сопротивление
reluctance motor синхронный двигатель с выступающими полюсами на роторе без возбуждения постоянным током
remote control дистанционное управление
remove *v* удалять, снимать
render *v* превращать, делать, оказывать
repair *v* ремонтировать, исправлять; *n* ремонт, починка
repel *v* отталкивать (-ся)
replica *n* копия, модель
repulsion *n* отталкивание
repulsion start motor репульсионный двигатель
repulsive *v* отталкивающий
reset *v* повернуть в исходное положение, устанавливать на ноль (повторно)
residual *a* остаточный, оставшийся
residue *n* остаток
resilient *a* упругий; эластичный
resist *v* сопротивляться, противопоставлять
resistance *n* электрическое сопротивление, активное сопротивление
resistive load активная (омическая) нагрузка
resistor *n* прибор омического сопротивления *(в эл. цепи)*, сопротивление
respond *v* реагировать, отзываться
response *n* реакция, отклик
responsive *a* легко реагирующий, чувствительный
restrain *n* сдерживать, удерживать
result *n* результат, исход; *v* следовать; *(from)* проистекать; *(in)* приводить к, иметь результатом
retain *v* удерживать, сохранять, поддерживать
retard *v* задерживать, замедлять
retentivity *n* остаточный магнетизм
reverse *v* реверсировать, переменить направление движения, переменить направление тока
revolve *v* вращаться
revolution *n* оборот, вращение
revolutions per second — r. p. s. обороты в минуту
rigid *a* жесткий, неподвижный
rigidity *n* жесткость
rocketry *n* ракетная техника
rod *n* стержень, прут
rugged *a* прочный
ruggedness *n* стойкость против износа, прочность

S

sag *v* оседать, провисать; *n* оседание, осадка
salt *n* соль
sample *n* образец, проба
sand-blasted base пескоструйная база
saturate *v* насыщать, пронизывать
saturation *n* насыщение, насыщенность
saw-tooth *a* пилообразный
scale *n* шкала
scan *v* развертывать, сканировать; *тел.* разлагать изображение; *n* развертка, сканирование
scatter *v* разбрасывать, рассеивать
scintillation *n* вспышка, сверкание
scope *n* масштаб, охват, сфера
screen *n* экран, экранирующая сетка
screen-grid tetrode тетрод с экранированной сеткой
seal запаивать, закупоривать
secondary *a* вторичная (обмотка)
seed *n* затравка, зерно, затравочный кристалл
segregation *n* сегрегация, расслоение
self-sustaining *a* самоподдерживающийся
select *v* избирать, выбирать

selectivity *n* избирательность, селективность
self-induction *n* самоиндукция
semiconductor *n* полупроводник
semi-conducting *a* полупроводящий
sensitivity *n* чувствительность
sequence *n* последовательность
sequencer *n* устройство, устанавливающее последовательность
sequential scanning последовательная развертка
series *n* ряд, серия
  in series последовательно
set *v* устанавливать; *n* ряд, комплект
set up *v* создавать, установить
set-up *n* установка
severely *adv* резко, сильно, тяжело
shaded-pole motor двигатель с экранированными полюсами
shape *n* форма
sheath *n* оболочка
sheet *n* лист (бумаги, металла); *эл.* пластина коллектора
shell *n* оболочка, электронная оболочка, трубка
shield *n* щит, экран; *v* заслонять, экранировать
shockproof *a* вибростойкий, стойкий при ударах
short-circuit *n* короткое замыкание; *v* закорачивать
shutter *n* заслонка, засов
signal-to-noise ratio отношение сигнал — шум
silicon *n* кремний
silver *n* серебро
simulate *v* моделировать
skin effect скин-эффект
slab *n* плита, слой, пластина
slant *n* склон, уклон; *a* косой; *v* искажать
sleeve *n* гильза (гнездо штепселя), корпус штепселя
slider *n* контакт, движок
slip ring контактное кольцо
slope *n* наклон
slot *n* паз, щель
slow down *v* замедлять
soft iron instrument электромагнитный прибор
solid *a* твердый, сплошной; *физ.* твердое тело
solidify *v* затвердевать
solution *n* раствор, разрешение (вопроса, проблемы)
solvent *n* растворитель
space *n* пространство, промежуток, расстояние
space charge пространственный заряд
spacing *n* расстояние, пространство
spacistor *n* спейсистор (полупроводниковый прибор)
span *n* перекрывать
spark gap разрядник, искровой промежуток
spark telegraphy искровая радиотелеграфия
special-purpose computer вычислительная машина особого назначения
special-purpose analog computer аналоговая вычислительная машина особого назначения
specific resistance удельное сопротивление
speed *n* скорость, быстрота
split *v* расщеплять, раскалывать
split phase motor двигатель с расщепленной фазой
spool *n* шпуля для катушки возбуждения; катушка обмотки возбуждения
spot *n* пятно; место; *v* узнавать, опознавать
spray распылять
spring *v* разбрызгивать
spurious *a* искусственный, ложный
square *n* квадрат, прямоугольник, квадрат числа; *a* квадратный
  square root квадратный корень; получение квадратного корня
stage *n* каскад, стадия, степень
stainless steel нержавеющая сталь
standing wave стоячая волна
starting torque пусковой момент
state *n* состояние
stationary *a* неподвижный, стационарный, постоянный

steady *a* устойчивый, постоянный
steam *n* пар
step down *v* понижать
step up *v* повышать
stiff *a* жесткий
storage *n* запоминающее устройство; элемент, память, хранение
storage battery аккумуляторная батарея
storage tube запоминающая трубка
store *v* запасать, хранить
strain *v* напрягать (-ся), скручивать, деформировать; *n* напряжение, деформация
stray *a* блуждающий, паразитный
stray capacitance паразитная емкость
stream *n* поток, течение
strength *n* напряженность, сила, прочность, сопротивление
strip off *v* очищать (провод)
stroke *n* ход
structure *n* конструкция, устройство, строение
sturdy *a* прочный, крепкий
subdivision *n* подразделение
subject *v* подвергать действию (влиянию); *n* предмет
submultiple *n* субгармоника
substitute *v* заменять, замещать, подстанавливать
subtract *v* вычитать
subtractor *n* вычитающее устройство
sulphuric acid серная кислота
supercooled *a* переохлажденный
super-speed computer сверхскоростная вычислительная машина
suppress *v* подавлять
suppressor *n* защитная (пентодная, антидинатронная) сетка
surface barrier поверхностный барьер
surge *n* волна, импульс напряжения, всплеск
surplus *n* излишек, остаток
susceptible *a* чувствительный, восприимчивый
susceptibility *n* чувствительность, восприимчивость
swamping resistance поглотительное напряжение, добавочное сопротивление вольтметра
sweep *n* развертка, качание, колебание
switch *v* переключать, включать, выключать; *n* выключатель, переключатель, коммутатор, ключ

T

tangent *n* тангенс; *a* касательная
tap *n* отвод, ответвление, зажим
target *n* цель, антикатод
technology *n* технология, техника
ten-column desk пульт с десятью колонками; магазин перфокарт с десятью колонками
tension *n* напряжение
tend *v* стремиться, иметь склонность
term *n* срок, термин; *v* называть, выражать
terminal *n* зажим, конец
terminate *v* кончаться, заканчиваться, ограничиваться
terrain *n* местность, территория
test *v* испытывать
therein *adv* здесь, там
thermionic *a* термоэлектрический
thermocouple *n* термопара, термоэлемент
thin out *v* редеть
thread *v* пронизывать, нарезать резьбу; *n* резьба, нарезка
thus *adv* так, таким образом
tight *a* плотный, непроницаемый
time *v* синхронизировать, хронизировать
tip *n* кончик, наконечник
tolerance *n* допуск, допустимое отступление
torsion *n* кручение, закрутка
tower *n* башня, вышка, опора

trace *n* след, незначительное количество; *v* проследить
tracer *n* прибор для записи (характеристики, кривой, повреждения)
tracer atom *n* меченый атом
train *n* серия, последовательный ряд
transcend *v* превышать, выходить за пределы
transfer *v* переносить, перемещать, передавать; *n* передача, перенос
transfer instruction *n* команда передачи управления, команда перехода; команда переноса
transistor *n* транзистор
transition *n* переход
translate *v* преобразовывать, переводить, объяснять
transmit *v* передавать, транслировать
transmission *n* передача
transmitter *n* радиопередатчик, *тел.* микрофон
transmute *v* превращать
transmutation *n* превращение
transparent *a* прозрачный, просвечивающийся
transverse *v* пересекать, скрещиваться
transverter *n* трансвертер, преобразователь переменного тока в постоянный
traverse *v* пересекать, скрещиваться
trigger *n* триггер, пусковая схема; *v* запускать, отпирать
trouble-free без неполадок, безаварийный
tube *n* трубка, лампа (электронная)
tune *v* настраивать, звучать
tuning-fork *n* камертон
tungsten *n* вольфрам
tunnel *v* проникать сквозь потенциальный барьер
turn *v* повернуть (-ся), навивать (обмотку)
turn into *v* преобразовывать, превращать; *n* виток, оборот
  turn on включать
  turn off выключать
turns ratio отношение витков обмоток трансформатора; коэффициент трансформации
two-dimensional *a* двумерный, плоский
typewriter *n* печатное устройство; пишущая машинка

U

underlie (underlay, underlain) *v* лежать в основе
unidirectional *a* однонаправленный
unit *n* единица, целое; агрегат, секция, узел, блок, элемент
unit bead бусинка
unit magnetic pole единичный магнитный полюс; единица магнитной массы
unit of digit единица числового разряда
unlike *a* непохожий на, разнородный; *prp* в отличие от
unlike poles *физ.* разноименные полюса
unlike charges *эл.* разнозначные заряды

V

vacancy *n* пустота, промежуток
valence *n* валентность
  valence band валентная зона
  valence shell валентная оболочка
value *n* значение, величина
valve *n* электронная лампа
valve amplifier ламповый усилитель
vaporize *v* испаряться
variable resistance переменное сопротивление
varistor *n* реостат, величина которого меняется от приложенного напряжения
varnish *n* лак
velocity *n* скорость, быстрота; частота
versatile *a* многосторонний, гибкий, универсальный

vibrate *v* колебаться, вибрировать, звучать
vibration *n* колебание, вибрация
vice versa *лат.* *adv* наоборот
view *v* осматривать, рассматривать; *n* осмотр, вид
visible *a* видимый, явный
vision *n* зрение
virtually *adv* фактически, в сущности
voltaic cell гальванический элемент
volume *n* объем, громкость, тон
volume control регулировка громкости

W

wafer *n* пластина, плата, диск
waste *n* отходы, потеря; *v* терять, бесполезно затрачивать
wave *n* волна
wave length длина волны
wedge *n* клин
wedge shaped клинообразный
weigh *v* весить, взвешивать (-ся)
weight *n* вес
wind *v* наматывать, обматывать (-ся)
winding *n* обмотка
wire *n* проволока, провод
wireless *a* беспроволочный; *n* радио
withdraw *v* брать назад, удалять (-ся)
word *n* код, число, группа символов, кодовая группа
work function работа выхода
wrap *v* завертывать
write *n* запись, записывание
write circuit схема записи
writer *n* записывающее устройство

Y

yield *v* давать, производить
yoke *n* ярмо

Z

zero *n* нуль

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