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Учебное пособие предназначено для студентов 2 курса всех специальностей и имеет целью подготовить их к самостоятельному чтению научно-популярной литературы на английском языке.

Пособие состоит из текстов, охватывающих технические разработки и инновации в различных областях науки и техники. Они предназначены для самостоятельной работы студентов по обучению различным видам профессионально-ориентированного чтения.

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A computer learns to translate

For 35 years researchers have been working on developing a system of high-quality machine translation. So far the progress has no been encouraging. Words with several meanings so natural for the developed languages, the difficulties of transmitting complicated grammatic nuances is a formalized manner, and the uniqueness of each language - this is far from the complete list of complications that researchers come across in their work.

"But the main difficulty is to leach the computer to understand the meaning of the text", says Yuri Apresyan, head of the department of theoretical and experimental linguistics at the Institute of Scientific Technical. Information and Technico - Economic Research in the Electro technical Industry (informelektro). This is what the designers are racking their brains about.

What does it mean for a computer to understand the meaning of a text? Must I think? No, of course this is not the problem. The aim is to leach the machine to discern semantic links in sentences. We already know that a computer can learn and memorize rule or any other formalized information much better that its teacher. But how to formalize semantic links between words in phrases?

This is actually, the main achievement of Apresyaifs department. Its staff found a way to formalize logical links between words to form a complete idea. It turned out that these links have quite a few formal shades, it is only necessary to find the method, suiting the case, of recording them in the machine's memory, and adjusting the programme in such a way that the computer is left without any "loophole" to mix various rules or principles of phrase construction. Then what the machine has to do is to produce a normative translation, as linguists say.

I had an opportunity to visit the machine room of inform electro, where the Iris-50 computer, made in France, is making its first steps translating from French into Russian. Of course, the origin of the machine has nothing to do with it. More than that, as Leonid Tsinman. The "chief mathematician" of the system, explained, the authors of (he new project would be happy lo replace their old iris, which is already over the ten-year limit, with a modern EC 1055 computer. This is because iris takes from 1.5 to 2.5 minutes to translate each phrase, which is too much for a machine, say the experts.

However, this, as well as the inconvenience of reading "outlet" sentences on the display screen written in Latin transcription, are not the most important things to be concerned about at the experimental stage. The main things is that it is easy to disclose the high "qualification" of the computer. Its translation does not need any editing, "the phrases are correct stylistically and grammatically, and the commas and periods are all in the right places.

When I was there iris was being tormented with a variety of difficult problems. The computer was given a construction translated into Russian by means of a phrase which is not characteristic of the French language (iris, for example, deduced a short form of an adjective, which does not exist in French). Then it was given a phrase in which even a person finds difficult to determine right away just what word refers to which. Sometimes, a tricky phrases is invented and the iris translates. Thanks to a skillfully compiled service programme, the machine successively described each ofits steps: what it does, how it does it and why.

The programme make the machine translate each sentence in only one version, without variations. This makes the task much more complicated. Viktor Rozentsvieg, a well-know specialist and professor at the Maurice Thores institute of Foreign Languages, well familiar with this subject, asked his fifth-year students to translate French sentences chosen from those translated by the inform electro iris. The student successfully coped with the task but none of them did it better or quicker than the computer.

The computer's memory keeps about 5000 French words and 7000 corresponding Russian ones. They were selected according to the frequency principle. A yearly file of the French electro technical journal was taken and the words which were found in the text more that once were selected. They constituted 95 per cent of all the words found in the journal in a year. The Russian equivalents were selected by the staff members.

The system works as follows: the task is fed to the computer through the display. The first programme block is switched on and the machine makes a morphological analysis of the text. Producing a word for word translation, it then writes out the initial words in a column and analyzes them according to gender, number, case and so on. Then the second block is switched on a syntactic analysis which determines the dependence of words in a sentence, builds the tree of these dependences and hypotheses of likely links. The programmes themselves suggest possible relations between words in a sentence there are 50 coded French "relations" in the machine language and more than 40 Russian. Each "relation" contains several rules which guides the computer in its searches.

Now for the translation itself. The "block" of translation rules is linked to the "block" of syntactic synthesis of Russian. This helps the computer lo build the sentence without any mistakes.

Researchers had to work hard before the machine could really work well: in the beginning the computer would mix up a word (meaning that its indications were not recorded correctly), then it would choose a logical connection between words that distorted the meaning, and so on. Therefore, new, more rigid limitations had to be introduced into the programme, in order for the computer to "leand to discern what was what.

So far the system can translate several hundred words. But even with this limited number of words it is can cope with all kinds of linguistic difficulties. New groups of words are added daily to its vocabulary. Translation programmes from English into Russian are also being pared. Thanks to the universality of the system, the inclusive of a new language into the computer will take much less time and effort.

Another stage of the machine's operation has already been worked out – a thorough syntactic (or semantic) analyses to rule out all mistakes.

Nevertheless, the designers of the system modestly believe that only the first step has beers made thought it must be said that this step is far from being an ordinary event.

Translating machine in epicentre of 'outburst'

At the MUMM Translation Centre (AUTC) a theoretical model has been developed on the basis of which an English-into-Russian automatic system of machine translation (Russ. abbr. AMPAR) has been created. The system was highly appreciated at an international seminar on machine translation held recently in Moscow by specialists from the USA, Canada,.England, the FRG, Sweden, Japan and other countries.

The AMPAR is the first industrially operative system of machine transla-tion. It can translate 3 signatures (nearly 75 pages) of a technical text in an hour.

"Machine translation is extremely advantageous when handling a lot of similar material, where urgency has a substantial priority over quality," says professor Yuri MARCHUK, director of the AUTC.

Hidden reefs of grammar.

When in Russia and the USA they simultaneously started the development of the first computer-based systems of machine translation (Russ. abbr. SMP), great hopes were set on them. The SMPs were to render assistance in solving urgent problems. Under conditions of "an information outburst" the productivity of labour of translators has started to look like a needle's eye through which a camel should be dragged.

A well-founded misgiving has arisen that the exchange of scientific and technical information may be slowed down because of inadequate speed of translation. It seemed that it would be sufficient to enter the dictionaries and basic grammar rules of two languages, say English and Russian, into a high-speed computer, and the problem would be solved. But almost immediately "hidden reefs" have turned up in connection with polysemies of words. For example, without any difficulties man mechanically selects, just that meaning of a verb which is required by a neighbouring noun. Such "mechanical" operations are uncharacteristic of the machine.

Joint work with man.

The theoretical mode developed in the AUTC is a model of translation by translation correspondences. The AMPAR reproduces, as it were, the actions of a translator who comprehends the meaning of a sentence, selecting corresponding notions in the native language without sinking into the niceties of grammar if not urgently necessary. To make the AMPAR system able to cope with the difficulties arising because of the polysemy of words, it has been provided with a so-called contextological dictionary.

Any of the modern SMP systems can handle only a pair of certain languages, and only in one direction. The AMPAR system, for instance, can translate from English into Russian. For a Russian-into-English translation, an independent system of machine translation is required. All the modern SMP systems, as well as translators, can work within the limits of specialized subjects. Nevertheless, all of them should be based on sufficiently powerful computers Otherwise, they won't be able to store all the varieties of the language's nuances. Moreover, it's desirable that the text entered into the machine is prepared for translation by replacing, say, "small ball" in the original with "ball", which is surely included in the SMP dictionary. If an unprepared text is entered into the machine, the translation received is usually of a poor quality and requires correction by an editor after the translation, which, naturally, takes time, thus reducing the basic advantage of machine translation, which is its high speed. But if the SMPs up to now have been unable to work instead of man, is it worth bothering with them at all Specialists unanimously maintain it is, but the SMP should not substitute for man, rather it should work jointly with him However, fields of application of the SMP systems have taken shape where they practically substitute for a translator. This relates to translating standardized technical papers for equipment, machine tools and machinery. Patent documents will be subsequently translated, too.

The development and testing of the potentialities of new SMP systems is earned out in our country on a sufficiently extensive scale. AUTC specialists have developed, apart from the AMPAR system, a German-into-Russian automated system of machine translation (NERPA) and a French-into-Russian automated system of machine translation (FRAP).

The machine translation systems now make a certain contribution to solving the basic problem facing the scientific and technical translation industry, which will considerably raise the productivity of labour of translators.

An automatic webster.

The work of AUTC specialists has ' shown that the development of the machine translation systems is by no means justified for all languages. One has to translate, for example, from Portuguese into Russian far less frequently than, for example, from English. When such a need arises, it will be more reasonable to entrust the translation to a person. But herein he should be rendered assistance. Calculations have shown that a translator's lab our productivity is doubled if he is saved the trouble of. turning the pages of a traditional paper-printed Webster dictionary.

Automatic dictionaries developed by AUTC specialists cannot, of course. Compete with either the AMPAR system or with other systems, and yield to them considerably in the translation speed. But such dictionaries provide translators with important conveniences.

All the automatic dictionaries have been made polylingual, including at least four languages, and symmetric, i.e., it is possible task a question and receive an answer in any language in the dictionary. As distinct from SMP. the dictionaries cover a variety of subjects. Yet, should a translator wish, the dictionaries can provide him with the meaning of the words relating only to the subjects of the text under translation. If there is no need for such selectivity, the automatic dictionary, also at a translator's. request can provide all the meanings of words along with examples of their use and explanations, simultaneously citing the references. Handling the automatic dictionary, a translator can receive either all the meanings of the required words, without further explanation, or only their first meanings, or the newest meanings of these words.

A translator can hold a dialogue with the dictionary, inquiring about unfamiliar words and receiving an answer on a television display screen. A batch-job mode of operation has also been provided In this case a translator underlines unfamiliar terms in the text. Then the marked text is entered into the machine and a printer produces an answer in the form of a microdictionary.

Automatic dictionaries considerably surpass the SMP systems in the number of words in storage, and they are easily updated with new terms.

One of the latest works of the AUTC specialists is an automatic five-language dictionary based on the EC 1022 computer using this dictionary, a translator can handle English, Russian, German, French and Hungarian texts.

Genetics

The word *genetics* is derived from the Greek word *genesis* which means *descent.* It is the science which deals with heredity. Genetics tries to discover the mechanism whereby qualities are inherited from parents to offspring. This science also attempts to predict the outcome of particular matings in certain animal and plant species. Genetics is a comparatively recent science and as yet we know relatively little about heredity in man. Genetics is also of great theoretical interest, since modern theories of evolution are based on the science of heredity.

During the early part of the nineteenth century many investigators studied the problem of the instability of hybrids. They found that certain types of inheritance were frequent in particular hybrid matings, but their experiments were not carried out on a large enough scale to allow them to predict the proportions of the various offspring obtained fay the mating of hybrids nor were their experiments numerically recorded and analysed.

The first large-scale and carefully controlled experiments on heredity in plants were carried out by an Austrian named Gregor Johann Mendel (1822—1884).

Mendel's experiments were carried out on peas. That particular kind of plant proved to be suitable for his work for the following reason:

there are a number of varieties, which are easily distinguished by differences in height, shape and colour of seeds.

In his first experiment which Mendel describes he chose the form and colour of the seed for study. One variety of the plant had smooth round seeds, while another variety had wrinkled seeds.

Mendel crossed these two varieties of plant and observed that only round seeds were produced. Continuing this experiment, Mendel allowed the hybrid plants which formed these round seeds to pollinate themselves, and produce seeds. From 253 hybrid plants 5474 round seeds and 1850 wrinkled seeds were obtained. Further experiments showed that about one-third of the round seeds behaved like the original round seeds of their grandparents and produced round-seeded offspring only, while the other two-thirds resembled those seeds which formed their hybrid parents. It appears that approximately one half of the offspring of hybrid parents resemble their parents, while the other half has equal chances of resembling either one or the other grandparent. By means of these experiments Mendel showed that inheritance of certain characteristics, at least, could be predicted with reasonable accuracy, since the types of offspring of hybrid crossed appears in definite numerical proportions. The experiments on hybrids, which form the earlier part of Mendel's work, showed that, in some cases, the inheritance of characteristics could best be explained in terms of factors or genes.

Subsequent research made by many investigators in different countries has confirmed Mendel's ideas but showed that inheritance is often complicated by the influence of various conditions, environment in particular.

The Mendelian factors, or genes, are found in the chromosomes of the nucleus; there is evidence that nucleic acids, also found in the nucleus, are related to genes.

Cell division and DNA.

There are three main parts in every human or animal cell. First, it has a thin outside shell called a cell membrane. Inside the cell there is a small, rounded body called the nucleus. Filling the rest of the cell is substance called cytoplasm.

Within the nucleus there are threads of material called chromosomes. The chromosomes are important in the process of making new cells. The chromosomes make copies of themselves and then separate. The cell splits into two cells and each contains chromosomes.

All attempts to separate the nuclei failed for a long time. Work continued on cells until it was shown that the nucleus alone determined how the plant would grow.

Soon it was found that all viruses contain nucleic acid and a protein shell.

It was discovered that there are two nucleic acid "brothers" — deoxyribonucleic acid and ribonucleic acid —DNA and RNA.

It was learned that a little string of DNA hidden in the nucleus of a cell stores and then sends from one cell to another all the information necessary to create a new living thing. We know that to build even the simplest house requires pages of drawings, details and measurements. How could these little pieces contain plans for a living being? It seemed impossible, but everything indicated that DNA did the job.

By 1953, the scientists had discovered much more about DNA. They knew that DNA was a huge molecule. They knew that it contained sugar molecules and phosphate molecules that were joined to each other. In addition to the sugars and phosphates, there were four bases that are called A, G, C and T.

There were thousands of these six different pieces, each with its own shape and size, in the DNA molecules.

Some scientists tried to build a model of a DNA molecule. They began to build it using wire and many pieces of metal. Each piece of metal represented a piece of the DNA molecule, cither a sugar, a phosphate, or one of the bases. The wire was used to hold the metal pieces to each other. They tried many times to fit the pieces together. They found that the pieces would not fit where they placed them. Each failure taught them more about the arrangement of molecules within DNA. They realized that only one model would be correct.

Finally the pieces began to [it into the right places. The phosphates and sugar molecules formed long curving lines. The four bases were attached to them to form a ladder. The sides of the ladder were made of the sugars and phosphates. The steps of the ladder were the bases — A, G, C and T.

But the bases were of different sizes. A and G were bigger, longer; C and T were smaller, shorter. How could there be a ladder with steps of different sizes? They discovered that two bases were required for each step. Each step had to contain one long base and one short base. Even so, there are four possible arrangements of the bases that form these steps. The whole truth then was that all DNA molecules had the same six pieces [{sugars, phosphates, and four bases) and all were in the same shape (a curving ladder). Only one thing could change — the order of steps.

The DNA was found in the nucleus, the RNA — in both the nucleus and cytoplasm, the substance of the cell outside the nucleus. Experiments showed that RNA moved from the nucleus out to the cytoplasm. The DNA contains the directions for making the living material. Within the nucleus, in a way as yet unknown, the DNA passes its protein manufacturing instructions to the RNA. Then the RNA goes out into the cytoplasm to help in the manufacture of the proteins. In 1955 some

RNA was synthesized in a laboratory. One year later some DNA was made.

A drop of blood.

Do you know that we have between 250 and 300 million red cells in each drop of blood?

As for the white cells there are only about 350 to 500 thousand of them in a drop of your blood so long as you are in good health. But suppose' you get an infection — appendicitis, for example. Almost immediately the number of white cells begins to increase until you may have as many as a million and a half in a drop of blood.

The disease germs produce certain chemicals in the body. These chemicals make the white cells divide, so that each white cell produces two new cells. The chemicals also stimulate the movement of the white cells toward the place where the germs are causing the infection. Then, when a white cell is close to a germ, it is further stimulated to change its shape. It wraps [2] the germ up. The germ is now inside the white cell, which then proceeds to digest it. So we can say that the white cells really eat up disease germs. Our blood also has proteins in it. And it has a lot of little cells called platelets, which contain a special chemical. Ordinarily, of course, this chemical stays inside the platelets. But, suppose, you cut your finger. The blood comes to the surface of the wound and the platelets break down. The chemical is released and it starts to affect the gelatin — like protein in the blood, building a network of fibres. Soon the network is big enough to form a jelly-like stopper for the wound. We say that the blood has clotted and the wound stops bleeding.

Proteins.

Protein molecules are the largest and most complex of all molecules; they may be up to ten million times as heavy as a hydrogen atom' and be built of many thousands of atoms — mainly of carbon, hydrogen, oxygen and nitrogen. Proteins are the fundamental units of living material; among other compounds of vital importance they include the enzymes, which bring about most of the chemical changes in protoplasm. Proteins are built of units called amino-acids. When a protein is treated with acid it will break up into chains of molecules called peptides and finally into amino-acids.

There are about twenty different kinds of amino-acids, the molecules of which vary in size from a molecular weight of 90 to one of about 250. An average protein molecule contains about 500 amino-acid molecules. In order to appreciate the complexity of a protein, we may compare the molecule of a typical carbohydrate (glucose built of 12 atoms), a fat (about 170 atoms), and a protein. The protein lactoglobulin, found in milk, has about 5940 atoms in the molecule.

Carbohydrates, fats, and proteins are very important in living material, but there are many other substances, such as the nucleic acids, vitamins, etc. which play a vital part in living organisms. The human body consists approximately of 65 per cent water, 15 per cent protein, 14 per cent fat, 5 per cent inorganic salts, and about 1 per cent of other materials.

Robots working beneath the sea.

The increasing versatility of unmanned, robot submersibles is coming to the aid of an offshore oil and gas industry moving into depths beyond the limitations of human divers. No longer just a "swimming camera" capable of observation alone, the remotely controlled undersea vehicle tethered to a mother ship today can carry tools for cutting, cleaning, and a multiplicity of other tasks required for such deepwater jobs as inspection and repair. The technology is still evolving, as drones linked to the surface by radio waves alone conduct topographic surveys or search for minerals on a seabed often hundreds of meters below.

With a remotely operated vehicle (ROV) there is virtually no limit on working time, no expense [or breathing gas, and none of the time and money involved in decompression of divers at the end of an assignment. This is an important factor when production wells operate in water depths of approximately three hundred and five meters—the working limit for most commercial divers—pipelines are installed at six hundred meters below the ocean surface, and exploratory drilling reaches to depths of fifteen hundred meters and beyond.

Currently, use of an unmanned underwater craft falls into one of three categories—surveillance, light work, or heavy work—but each manufacturer or user defines them in their own way. And the definitions are often applied loosely.

The remotely operating vehicle is a self-contained unit capable of operating continuously—as long as surface weather permits. Electrical power, video signals, and electronic commands from the operating hut on board the mother ship are sent through an umbilical cord strong enough to lift the craft out of the water. Through this connection, one or two operators can manipulate the undersea unit and its two multi-tooled hydraulic arms as extensions of themselves—monitoring and controlling repair work as easy as if they were on the ocean floor. Manipulator- or robot- arms can be used, for example, to open or shut pipeline valves, and operate valves that help control the flooding of platform jackets when they are lowered to the seabed. The arms can locate and "feel" gaps during inspection or building, and retrieve drilling equipment, such as acoustic beacons used to position exploration and production units.

On the operating consoles of most tethered unmanned submersibles, the direction and speed provided by small thruster motors are controlled by a three-way "joystick", a term borrowed from the aviation industry because the ROV manoeuvring system is more like that of a helicopter than a boat. The remote unit generally does not have rudders or other movable control surfaces because a speed that rarely exceeds four knots makes such steering arrangements cumbersome. Instead, thruster motors provide movement in all directions—forward-back, up-down, side-to-side—so the operator can maintain tight control of the vehicle in the waters beneath him.

Industrial robots

Industrial robots are being used for a wide variety of tasks in factories, shops and foundries around the world. Robots unload parts from die casting machines and plastic injection moulding machines. They load and unload parts at machine tools and stamping presses; transfer parts from die to die or from press to press. In die casting and plastic injection moulding operations, a robot may unload a single machine or as many as three machines. In machine tool loading and unloading, the robot may also tend more than one machine—loading and unloading each in turn, or on demand and transferring parts from machine to machine, as well as placing parts in gages for dimensional checking.

In forging operations, robots are used to transfer hot billets from furnaces to forging presses, to transfer parts from die to die in successive forming operations and to handle hot and cold parts in trimming operations. Robots are also used in casting clean-up operations, handling cutting torches or abrasive cut-off wheels to remote gates and risers and for grinding flash from parting lines.

Continuous-path servo-controlled robots are used for spraying a wide variety of parts and materials; for spot and arc welding. Robots are used for drilling and grinding, handling either the parts or a power tool.

In assembly operations, the microprocessor-controlled robot with sensory feedback capability performs the complex part and tool-handling tasks.

Pneumatic industrial robots are usually recognized as a "pick-and-place" type, which moves between two preselected points. Linear movements are usually powered by double acting pneumatic cylinders. The double acting pneumatic cylinder is universal in its use with the added advantage of simple design for linear thrust and infinite control of thrust and stroke velocities using standard pneumatic control valving. Rotary movements are powered by pneumatic rotary actuators (torque units) which are hydro-pneumatically dampened.

Pneumatic robots have a load capacity of up to 15 kg, high stroke velocity up to 2 m/s, and are able to work under hard environmental conditions. The mechanical arrangements of pneumatic robots are simpler than hydraulic ones, in as far as air can be removed from any point of the system. Complicated transfer mechanisms are not needed for linear motions of manipulator members, for example in the case of electromechanical robots. Pneumatic robots cost 2-3 times less than hydraulic ones.

But pneumatic robots have some essential disadvantages. They are characterized by the drooping speed-torque characteristic. This complicates the creation of multipoint PTP pneumatic drives. Practically all the up-to-date pneumatic robots have the simplest cycle control system. Adjustable hydraulic shock absorbers are used at mechanical stop positions on pneumatic robots which distinguishes them from hydraulic and electromechanical ones.

A journey to the centre of the earth

What is the structure of the planet? If you put the question to a specialist he would tell you that first there comes the Earth's crust, then a molten layer (mantle rock) and in the very centre of the globe there is an iron core.

This pattern has been recognised by scientists in all countries.

It is usually thought that the upper layer, the Earth's crust, is very thick in continental regions — between 50-70 to 10 km, and thinnest of all under the oceans — some 6-10 km, no more.

The geologists, who are very interested in the Earth's mantle rock, are making all sorts of projects for super-deep boring. Naturally, they expect to carry out this work in the ocean. Since the crust is the thinnest there, this should imply that expenditure will be less, too.

However, drilling in the ocean is still a tremendously complicated job.

Since none of those projects have yet been carried out, the scientists are employing indirect methods of probing the terrestrial depths — seismological, gravitational, etc.

Now yet another method has been evolved. It involves using the electromagnetic waves in the broad range of low, infralow and medium frequency bands. We use frequencies of from hundred of kilocycles down to thousand of a cps[1] to study the structure of the Earth beginning at about 10 metres and going down as far as a hundred kilometres and even further.[2] The higher frequencies are used to get information from the upper layers and the lower frequencies — from the deeper ones,[3]

Our scientists have built wide-range generators[6] from which the electric current of various frequencies is discharged into the Earth. A receiving device is placed at a specified distance from the generator. The electromagnetic field, or the electromagnetic waves, discharged into the Earth, come back to the point of the surface where the receiver is, after they have passed through the various layers in the Earth's crust.

The wave after it passes through the Earth is being transformed in keeping with the structure of the Earth[5] and its properties at these depths. Hence, it brings with it information with regard to the structure[5] of the Earth's layers. The processing of these data and appropriate interpretation make it possible to draw significant conclusions. However, we can penetrate only some 10 km down into the Earth's crust with the aid of an artificial wave.

Below that level we have to make use of natural electromagnetic fields. Where do they come from? They originate in the ionosphere, one of the atmosphere's upper layers. The ionosphere is excited by solar activity and currents are generated in it which travel round the Earth at an altitude of some 200 km. They also penetrate deep into the Earth and hence make it possible for us to study its inner layers down ' to a depth of several hundred kilometres.

The natural electromagnetic field is less accurate since it defies control. Artificial fields allow for more accurate research because we can control them, and do whatever we ' like with them. This is most rewarding,' because when probing the Earth down to depths of several kilometres we must have considerable accuracy, since this research has also a very practical aspect, connected with the search for mineral deposits. We must be able to say whether the layer in question is[8] 1,000 m down or 1,030-1,050 m. The margin of error[9] is less than 5 per cent, otherwise those who are interested in mineral deposits cannot really utilise the data obtained.

With the methods of frequency probes we have evolved the necessary precision can be ensured. We have already experimented with the method in geological prospecting work in Kazakhstan, where it enabled us to find an oil-bearing area. At present boreholes are being sunk to test our findings and we are awaiting results. The oil-bearing area is at a depth of 3,300 m.

Sedimentary rocks are to be found at depths of about 3,000 m in Siberia. Below them come the igneous mother rocks in the form of hard granites. In some cases it is possible with the new method to identify the border of those igneous rocks and determine the depth of the surface layer of the bed down to

10-20 km. After that comes a layer from 20 to 100 km and even deeper. Only beneath this layer do we encounter[10] conducting layers. The rock at that depth is now believed to be in a molten state and, hence, capable of conducting electricity. So at a depth of about 100 km and lower we find a mass of rock which is nearly as good a conductor as metal.

In the Lake Baikal area the conducting layer can be found at a depth of about 60-70 km. Elsewhere— in the Ukraine, for example,— it is in some places 400-500 km down, and in others — 80-90 km down. Naturally there must be an explanation for this tremendous difference. Right now it eludes us and we can only speculate. In the Leningrad Region we penetrated down to 50-60 km and found a very good conducting layer from depths of about 5-6 km. This seems to be very specific and unusual. Clearly, the structure of the Earth differs greatly from area to area.

The electromagnetic method of research baffled scientists as soon as the first probes were made. All concepts about the structure of the Earth were upset.

The phenomenon discovered in the Leningrad Region was another riddle for the researchers. What is it? Volcanic lava of the Earth's upper mantle rock? Not likely. The Scandinavian shield was always calm and there was never any volcanic activity there. Maybe it is a huge layer of metal which can beautifully absorb electromagnetic waves? In that case the prospectors will soon find there fabulously rich mineral deposits. Or perhaps it is a huge salt sea? Saline solutions are also good electricity conductors.

Science has to tell us whether it is possible to probe the Earth accurately down to depths of several hundred km. The electromagnetic waves method will help in this. Then we shall have even more knowledge about our native planet, will discover more mineral deposits so necessary for the welfare of mankind.

Continent and continental drift

Continent is any of the major connected land masses of the Earth. There are six continents, Eurasia being regarded as a single unit. Together they form one of the two major divisions of the crust of which the other is the ocean basins. The two are very different in topography for at the continental slopes[1] the continents rise nearly 3 mi[2] above the ocean floors. The land masses are also more siliceous in composition and have different structures. Continental drift is the supposed process by which continents and islands are moving relative to one another across the face of the Earth. It was first proposed early in this century to explain similarities of outline observed between some coasts of adjacent continents e. g.[8] South America and Africa. Outstanding similarities were observed also in respect[4] to some ancient faunas, floras and aspects of glaciation which are the same in all the southern continents and the nearly parallel and matching opposite coasts of the Atlantic Ocean and the Red Sea.

One or perhaps two primitive continents were considered to have broken up about 200 million yr ago and to have drifted apart at a rate too slow to measure. The continents were regarded as slabs or rafts of siliceous rock drifting about in a viscous mantle of more basic rock. Mountains were considered to have been pushed up along the leading edges of continents or where "rafts" collided.

These and other theories have their supporters but there are many objections to them. Do continents drift? The precise answer to this question, which has intrigued scientists for a long time, will be supplied by the unified programme of research work now being done by the astronomers, geo-physicists and geologists of many countries. Soviet researchers have determined the movement of the Earth's poles over the last 60 years. It turned out that[6] the North Pole has been moving at an average rate of 11 cm per year in the direction of Labrador. However, it is impossible to declare that this movement was the same in the distant past, or that it is expected to continue in the future.

Towards a new ice age?

Antarctica continues to draw the scientific explorer.

Although Antarctica is of no direct value to mankind at present, except as a potential staging post for polar air routes in the southern hemisphere, it plays a major part in governing the world's climate. A significant fraction of the world's water is held there in cold storage and the inhabitants of virtually every major city in the world, apart from[1] such places as Mexico City, have reason to be thankful that it is so. If the ice cap melted we should all be flooded. The Antarctic ice sheet represents the core left by the passing of the last Ice Age and, like the Arctic ice, it is one of the thermostats which keep the planet cool and windy.

Except for a few episodes, including the present, the world has usually been free of ice, and balmy.[2] When there is ice around, it erupts periodically from its polar and mountain lairs, in a succession of Ice Ages. By current theories it is not too hard to see why it happens.

The land mass of Antarctica forms a kind of dome, down the sides of which the ice slowly edges towards the sea, producing a steady supply of icebergs. Nevertheless the pile-up of snow in the sheet makes it grow thicker, over the centuries, until the pressure is great enough to melt the ice at the surface of the underlying rock. Then the ice can move, not only by gradual deformation (plastic flow), but also by a much quicker mechanism of alternate thawing and freezing.

If, by this mechanism, it gathers speed, it will be accelerated further by heat generated by friction. The ice can then surge down towards the ocean — perhaps at a speed of around

10 feet an hour, which may not sound much until one reflects on the enormous mass on the move and the armadas of icebergs launched thereby into the southern ocean. By cutting off heat from the ocean, the outspreading ice must then cool the whole planet and let the Arctic ice cap grow as well. Even short of[3] a new Ice Age, a partial slide of the Antarctic ice could be serious enough, as it would set up huge tidal waves that would wreck harbours and coastal settlements in every continent.

There are plenty of other reasons for taking a scientific interest in Antarctica.

Water

Water is one of the commonest of all substances, and without it life would be impossible. The seas and oceans cover about seven tenths of the Earth's surface but water is also contained in the soil, in the atmosphere and in all living things. More than half of the human body consists of water, which also forms a large part of the food we eat, especially vegetables and fruit. Man can live as long as ninety days or more without food, but we cannot live long without water.

Water exists as a substance in three states: ice, which melts at O degrees Centigrade; liquid water and steam, the latter is formed when water boils at 100 degrees Centigrade.

Water differs from other liquids in that it expands when cooled from 0° Centigrade, contracts when heated from 0° to 4° Centigrade, and reaches its maximum density at 4" Centigrade. No other liquid possesses this property.

Pure water is rarely found in nature. This is because water is able to dissolve so many substances from the air, the soil and the rocks. The saltness of sea water is caused by the mineral substances which are dissolved from the Earth's surface by rivers and carried down to the sea. The Sun's heat causes the surface sea water to evaporate, or change into vapour, leaving behind the salt and other minerals. This explains why the seas are so much more salty than rivers flowing into them.

Ground water

Ground water is the water contained underground in the interstices of soil and rock. When rain falls on the earth some evaporates, some is absorbed by plants, some runs off in streams and the remainder sinks into the earth to become ground water. The amount that enters the ground depends on various factors: rain falling on loose soil sinks immediately; rain falling on clay either lies on the surface and evaporates or runs off; on steep slopes runoff will exceed absorption. Ground water exists everywhere in the earth's crust, generally not much deeper than about a mile.

The upper surface of this water is known as the water table. The height of the water table varies between wet and dry seasons and between humid and arid regions. In deserts the water table may be hundreds of feet below the surface.

The region that is sometimes above and sometimes below the water table is known as the zone of fluctuation. This zone through which the water table fluctuates is the place where decomposition of rock is most active. The relation between the contour of the water table and the topography or contour of the land is well marked. The water table rises to higher levels underneath the hills, and slopes to lower levels in the valleys, where it may appear on the surface in the form of springs, rivers, bogs, or lakes; but the slope of the water table is always less abrupt than the slope of the overlying land surface.

This ground water acts directly by taking into solution the soluble minerals (process of solution) and by adding molecules of water to the other minerals (process of hydration), and indirectly by bringing carbon dioxide to be combined with some of the elements in solution, such as calcium, to form carbonates (process of carbonation). Oxygen readily unites with most elements and this combination is made much more readily when water is present. As a result, we get oxides and hydrated oxides (process of oxidation).

Thus we see that decomposition of the earth materials is carried on very actively in the presence of ground waters. Since they are always seeking a lower level they may run out of the side of a hill as a spring or feed a stream or lake whose level is an indication of the height of the water table at that particular point. As this water seeps through the cracks, crevices, and holes in the rock beneath us, it takes some of the rock minerals in solution and transports them to lower levels, eventually to rivers that will carry these soluble minerals on to the sea. As this continues for a long period of years, what was originally an interstice or crack in the rock may be opened into a larger cavity, known as a cave.

Water cycle. Ground waters and surface waters both seep and flow to lower levels until eventually they reach the sea. They are usually laden with materials in solution or suspension, and when flowing as surface waters they may push heavier rocks along on the bottom of the stream. All of this foreign matter is left in the sea. As a result of the heat from the sun, the water evaporates into water vapor that is carried hundreds and thousands of miles by air currents until clouds are formed by the condensation of the water vapor about tiny dust particles, and a disturbance causes precipitation. The falling water goes over and through the ground to the sea, thus repeating the cycle.

What is the difference between surface water and ground water?

Just as the name implies, surface water is that fresh water which is accumulated on the earth's surface. Lakes, rivers, reservoirs, streams, swamps and any other natural storage basin contain surface water.

These areas are all open to the sky and accessible to rainfall. Not all surface water areas are natural, of course, as there are many man-made lakes and reservoirs. Rain, melting glaciers and underground water are all sources of replenishment for surface water bodies.

Ground water on the other hand is that fresh water (from rain, melting snow or ice) which soaks into the soil. This water first enters a layer of earth containing air and water surrounding rock fragments or soil particles. This particular area is called the zone of aeration. The water gradually replaces the air, as it seeps through the soil, until the soil is finally saturated. The top of this saturated zone is known as the water table (which was discussed before). At the bottom of the zone, very often is bedrock which can be 10 miles below the surface.

As the ground water moves through the saturated zone, it replenishes dry or low-water volume cavities in the ground which must have plenty of water if they are to keep lakes and wells supplied.[1] Sometimes vegetation draws water from the saturated zone upwards to its roots. Too, the water can become trapped deep within the bowels of the earth and remain in natural underground reservoirs for many years. Underground water is not limited to regions of the earth with high precipitation. Deserts, plains, many arid sections of the world, as well as mountains, rivers, cities, have a great deal of underground water. There is even underground water beneath the oceans.

If the water table in a certain region is at a ground level, then what will occur? A swamp, of course, for the soil is saturated at that point. If the table happens to be above the land's surface, then natural lakes or ponds are formed.

Where the atmosphere meets the ground

The lowest layer of the atmosphere which man inhabits is the region where much of the interaction between the free atmosphere and the earth takes place. It is here that all the' momentum of the atmosphere is absorbed and through which all the heat and moisture are exchanged between the Earth and the atmosphere. These processes constantly modify the environment and affect a range of major problems, from those of the farmer who is concerned with his crop to those of a power engineer concerned with dispersion of his combustion products.

The main physical process governing the exchanges of energy and matter in this "boundary layer" is natural turbulence. Turbulence is primarily generated by friction between the air which is in motion and the stationary ground. Typical time scales of eddy motion vary from fractions of a second to an hour, space scales from fractions of a centimetre to a kilometre. These are very small[2] compared to the scales observed in weather maps, hence the name "micromete-orology."

We know all about turbulence in wind tunnels but less about the real atmosphere where things are more complicated. Conditions change from day to night and from day to day. While the micrometeorologist's most productive tools are certain statistical concepts of fluid machines[3] and aerodynamics, much experimental work needs to be done before these concepts can be applied to the atmosphere. The problems of gathering, recording and processing the enormous volumes of data required for such a study has hitherto been a limiting factor.

This difficulty has been overcome with the use of a mobile computer-controlled system[4] which can automatically execute all data — gathering operations during a field experiment and subsequently perform the necessary data processing[5] and analysis as well. The system is housed in a van for convenient transportation to any experiment site.

Wind in motion

A wind is simply air in motion. If you blow up a toy balloon, so that the air inside it is under pressure, and then let go of the nozzle, the pressure at once drives the air out again and you can feel it as a wind. The air comes out because there is less air pressure outside the balloon than inside, and it is a general rule that winds always blow from high-pressure areas to low-pressure areas.

Now the atmosphere that covers the earth is liable to great variations in pressure, owing to the fact that[1] some places are warmer than others. Air contracts when it is cooled, so that cold air is packed more tightly together than warm air — it is at a higher pressure. Warm air, on the other hand, expands and because it occupies more space it is thinner than cold air — it is at lower pressure. Because it is thinner it is also lighter, and tends to rise like the hot smoke over a bonfire. In places where the air is simply risingor falling no winds are felt and these are regions of calms; wind is only felt when the air blows horizontally.

So we generally, use the term "wind" to describe only the horizontal movements of air across the- earth's surface. The chief reason for there being areas of high and low pressure is that the sun[2] does not heat the earth equally allover, much more heat being given to the atmosphere at the Equator than at the Poles. When air is heated, it expands and, becoming lighter, rises by what is called convection[3] so lowering the pressure near the ground and increasing it up above. This occurs all round the equatorial belt, with the result that the cooler high-pressure air from the polgr regions sweeps in at low level, while the warm equatorial air move's outwards at high level towards the

Poles. Here it is cooled and sinks, taking the place of the air now at the Equator.

Cat – monster in the sky

Several thousand feet high in the atmosphere lurks an invisible and treacherous force, which scientists have yet to understand. This is Cat, as aviators and meteorologists have nicknamed the menace called *Clear Air Turbulence.*

Cat can neither be detected nor foreseen by the highflying jet air-planes It threatens. At altitudes of as high as 40,000 feet in a clear blue sky, a plane will suddenly hit without warning a turmoil of air that puts enormous strain on wings and other structures. Planes have been known to flip over or drop several thousand feet in a few seconds. Seats have been ripped from their moorings, rivets popped from their sockets, and once an engine was twisted off a plane. Pilots have extreme difficulty controlling their craft, and passengers sometimes are severely hurt if they are flung around the cabin. Many unexplained crashes may be attributed to this mysterious creature of the sky. It has been suggested that Cat could fell any supersonic transport.

Scientists believe that Cat is caused by wind shear, which is a turmoil of winds moving at different speeds or in different directions, clashing and setting up whirls and eddies of air. There may be two energy sources where this takes place: "the jet streams, those capricious rivers of air that flow around the earth from west to east in the midlatitudes at 200 or 300 miles per hour or mountain waves, strong disturbances created by the flow of air up and over the crests of mountain ranges.

Unlike the familiar turbulence associated with thunder or storms which can be spotted on radarscopes and avoided, Cat cannot be detected by radar. Researchers are attempting to track the Cat with instruments recording changes in temperature or pressure, the presence of ozone or static electricity. So far they have not been successful. Nothing seems to indicate the presence of this invisible giant except the sudden bump when a jet hits it.

One of the latest and said to be the most promising means of detecting clear air turbulence (Cat) is an infra-red device.

Cat is a term used, to describe a disturbance in the atmosphere generally occurring outside a thunderstorm area. To date various methods for remote detection of Cat employing microwaves, lasers, radars and optical systems have been studied.

Ball lightning

A certain kind of lightning which has even top scientists stumped is ball lightning. This peculiar, often spectacular kind of- electrical discharge appears as a round or elliptical moving blob of light, sometimes about four inches in diameter, sometimes larger.

These strange baits, described in colors of red, yellow, white or blue, make their weird appearance at times of regular lightning. Some decay or dwindle slowly away, and others disappear with a sharp explosive pop.

They have been reported hovering motionless in the air a few feet off the ground, or travelling as fast as several hundred feet a second, sometimes, in erratic paths. They drift through the air, following air currents or even reaching against.the wind. They glide down trees and travel along wire fences. Some have even "chased" people around a kitchen table, or disappeared through a keyhole. One fell into a bucket of water and made it come to a slow boil.

Considerable controversies have been stirred up about these ball lightnings. Scientists say they may be optical illusions or figments of imagination, perhaps a clue to the world of flying saucers. Unfortunately sightings are rare, and few scientists have seen them. But characteristics seem to be consistent, and attempts have been made to explain them. Some scientists believe they originate at a place where the downward lightning stroke from the atmosphere joins a streamer of electrical charge rising from the ground. Others think it is a ball of recombining ions and electrons, at temperatures high enough to produce light. Precise laboratory experiments are adding to the growing evidence that ball lightning does exist. Aided by an electronic computer, Westinghouse Research Laboratories scientists have shown mathematically that known natural forces can explain it, and have drawn a model with many of the strange properties of ball lightning. They describe it as a luminous, high-temperature region of air having high electrical conductivity. Central temperatures may range from 3,500 to 6,000 degrees C, occurring when direct currents of electricity funnel through a particular region between the storm clouds and the ground, making the air in that region hot enough to glow. The glowing ball could hang stationary in space when the cloud-to-ground currents are symmetrical about it — but any change in these forces could cause the ball to move, the researchers say.

Ultrasonics

Ultrasonics is the name given to the study and application of sound waves having frequencies higher than those to which the human ear can respond (about 16 kc/s). The subject may be divided into two sections, one dealing with low amplitude vibrations and the other with high energies. For low-amplitude propagation one is concerned with the effect of the medium on the waves; permanent changes do not take place in the medium. For high-energy applications, however, one is concerned with changes brought about by the waves in the medium.

Low-amplitude waves are passed through a medium in order to measure its propagation constants, i. e. velocity and absorption coefficient. The techniques employed for this purpose are applied to the non-destructive testing of materials and to instrumentation. Reasons for using ultrasonic frequencies, as opposed to audio-frequencies, include:

a) shorter wavelengths occur at higher frequencies so that plane wave conditions are more easily realized. This is especially important for small specimens;

b) absorption coefficients are usually much higher and thus more easily measurable at higher frequencies;

c) frequencies associated with relaxational phenomena often fall within the ultrasonic range.

High-energy applications include cleaning, drilling, chemical processes, and the production of emulsions. These are carried out either directly by the agitation of the waves or through the phenomenon of cavitation. Some of these operations can be performed at audio-frequencies and quite often the only reason for using ultrasonics is that the process is inaudible. An important advantage of using higher frequency waves is that they are more easily focussed.

One of the first applications of ultrasonics was in 1883 when Galton devised a high-frequency whistle to measure the upper frequency limit of response of the human ear. Even at this time both the piezoelectric and magnetostrictive effects were known but it was not until a sufficient degree of progress was made in the study of electronics that they could be used[3] for the generation of ultrasonics.

The first important use of ultrasonics was made by Langevin during the 1914-18 war for underwater soundings. From then on slow but steady progress was made in the measurements of propagation constants of materials. Early landmarks included Pierce's quartzdriven ultrasonic interferometer in 1925 and the discovery in 1932 by Debye and Sears and also by Lucas and Biquard of ultrasonic diffraction grating. Pierce's observation of velocity dispersion in carbon dioxide and the work done in 1928 by Herzfeld and Rice on thermal relaxation showed that ultrasonic measurements could produce valuable information about the physical properties of the materials in which the waves were propagated. An important event during the 1930 was the pioneering work of Sokolov in 1934 on ultrasonic flaw detection.

It was not until after the Second World War that any major advances were made in ultrasonics. The discovery of radar led to the development of the pulse technique and its applications to the non-destructive testing of materials and to medical diagnosis. At the same time considerable advances were made in the application of high-energy ultrasonics to industrial and medical processes.

Much scope exists for further developments In both low and high energy ultrasonics. New materials are now being used for the design of transducers, especially with a view to obtaining higher intensities and much progress is being made towards the production of very high frequencies comparable with those of the thermal lattice vibrations of materials.

Ultrasonic applications

Not so long ago, ultrasonic waves which are inaudible to the human ear were known in the laboratory only. They now have various uses in industry, science and medicine.

The commercial use of ultrasonic waves depends on the power of the oscillations. In human speech, for instance, this is negligible. The population of Moscow, Paris and London would have to shout for two days without a stop to boil a litre of water.

The average human voice generates a power of several thousands millionths of a watt. The excess pressure added to the atmospheric pressure when a big symphony orchestra plays at its loudest does not exceed the pressure exerted by a tiny fly alighting on a dry leaf floating on water.

Modern technology, however, can produce audible and ultrasonic oscillations, with powers measured in kilowatts, with intensities measured in scores of kilowatts per square centimetre and with excess pressures in scores and hundreds of atmospheres!

Under the action of intensive ultrasonic oscillations matter acquires acceleration thousands of times greater than that due to gravitation.

Ultrasound can disintegrate super-hard alloys and porcelain. The diamond, reputedly the hardest substance, breaks up under the action of ultrasound. At the same time, ultrasound can do the most accurate and delicate work. It can bore 1/10 millimetre hole through a diamond with tolerance of one micron. This capability is widely used in industry and other fields.

Soviet scientists and engineers have developed new models of ultrasound machine tools (4770, 4772A, 4773A, etc.) which besides their high technological standards have an output 3-4 times that of the finest models made in the United States, Britain and West Germany.

In fractions of a second ultrasonic energy can cleanse impurities from the surface of the most intricately shaped part, making it far cleaner than by any other method.

The cleaning of goods in fluid subject to ultrasonic pressure is quite efficient and cuts costs many times. Our industry manufactures this equipment.

Ultrasound is used at our enterprises for welding together gold and germanium, aluminium and steel, which cannot be welded by other means.

More varied industrial application of ultrasonics are being found. Industry is demanding many ultrasonic machine tools, machines for cleaning, welding apparatuses and other highly productive equipment.

Ultrasound is widely employed in medicine. Recently we developed an ultrasonic bio-radar for locating a medical disorder. It is based on the fact that in different live tissues ultrasonic waves are propagated differently.

This instrument, among other things, makes possible the detection of such foreign matter as wood and glass in muscular bony or fatty tissues which cast no shadow on the X-ray film.

An eye tumour has been located by ultrasonic reflection.

Until recently quartz and nickel were used as the sole source of ultrasonic oscillations. However, quartz is scarce, costly, difficult to work since it needs high electric furnace temperatures and its efficiency is low. Nickel is heavy, costly and demands intricate processing.

New sources of ultrasonic energy have been found in synthesised ceramics which are strong, cheap and easily obtainable.

Quartz was replaced by piezoelectric ceramics. Nickel and related alloys are ousted by ceramic magnetostrictive ferrites.

Ferrite emitters convenient in operation and highly efficient, have been developed. They are particularly useful in making small ultrasonic implements. Thanks to their insignificant power losses they heat only slightly in operation and do not require special cooling.

Ultrasound, like a beam of light, can be focussed to yield

a still greater concentration of sound energy. This made it possible to develop super-powerful ultrasonic concentrators—machines with tremendous intensities of the ultrasound and high pressures at the local point.

In one such instrument an intensity of 100,000 watts per square centimetre was obtained on an area of 1/10 of a square centimetre. This corresponds to a sound pressure of almost 600 atmospheres.

These high intensities produce unexpected transformations of matter, thus opening up prospects for new scientific and technological uses of ultrasound.

Heat

In ancient times people thought that heat was a material just as air is. They called it *caloric.* When something got warm, they said, caloric flowed into it. When something cooled off, caloric flowed out of it. It did not bother them that they could not see caloric. They could not see air either.

Now we know that heat is not a material. It does not take up any space. It does not weigh anything. It is a form of energy. Saying that heat is a form of energy means that it can be used to do work. When we see an automobile speeding down a road, we can be sure that it is being driven by the heat of burning gasoline.

There are many ways of producing heat. Fire, friction, and electricity are three of them. All of our ways of producing heat, however, would not keep the Earth warm enough for us to live on it if it were not for the Sun. In the Sun changes are going on that keep it so hot that we can hardly imagine how very hot it is. It has given the Earth heat for millions of years. It will keep on giving the Earth heat for millions of years to come.

Heat travels much better through some materials than through others. It travels easily through metals. We say that they are good conductors of heat. Wool, asbestos, and still air are three of the many poor conductors of heat. We use poor conductors to shut heat in or to shut it out. Heat can also travel without the use of any material conductor. The Sun's heat reaches us across almost empty space in the form of rays which the Sun, sends out.

Most substances expand, or get bigger, when they are heated. Engineers must allow room for expansion when they build concrete roads and steel bridges. Heat brings about many other changes in materials. Heating some solid substances makes them melt. Heating liquids makes them change to a vapour, or gas. In many foods heat brings about changes which make the foods pleasanter to eat.

Cold means absence of heat. We can cool something only by making heat travel out of it. In a refrigerator we do not put cold into the food. We take heat out. Knowing how heat can be produced, how it travels, and what kinds of changes it brings about is important to all of us.

Very long ago people came to the idea of heating their homes. The idea of heating with fire is not new. Thousands of years ago the cave-men were using fire for heating. The Romans worked out a way of heating all the rooms In their houses with one fire. The fire was built in a room called the atrium. "Atrium" means "black room". It got its name from the soot that coated its walls. From this room hot air was carried through pipes to the rest of the house. Heating all the rooms of a building from one source of heat is called central heating. After the days of the Romans, the idea of central heating was given up for 1,500 years. People went back to the idea of a fire in each room. And only much later central heating became popular again.

21st-century transport

It has been a long time since train velocities first surpassed the 100 km per hour limit and they are now approaching 200 km per hour and even higher in some countries.

But population growth, its mobility, the very tempo of life requires ever greater speeds from ground transport.

Is it possible to increase the speed with the help of the traditional wheel at the present stage in the development of transport facilities? Scientists and engineers in various countries have come to the conclusion that a new leap in velocity is possible only if the wheel is replaced with an air or magnetic cushion. While two or three decades ago the idea of "flying trains" was limited to sci-fi, today it is being developed in earnest by scientists and engineers in various fields.

In Russia the Electrical Locomotive Engineering Research Institute is the leader in the development of high-speed ground transport. In collaboration with many other research centres, it is carrying out an extensive programme on high-speed ground transport.

The institute's testing ground is situated near the Novocherkassk electrical locomotive plant. A two-layer metal band is installed in a 30-metre-long shed. This is the rotor, part of the electric motor line which moves the coach. The other part - the stator - is fixed on the motor coach. A switch clicks and the three-ton structure hangs in the air. It seems that simply pushing the cabin by hand will make it move along the band. But no physical efforts are needed. The 400 kw motor accelerates the structure up to 50 km per hour. A higher speed is impossible because of the shortness of the track. But the track length is sufficient for the numerous laboratories that are located in the shed, engaged in developing a control system for the magnetic suspension project, as well as in power supply, current pick-off, brakes, the optimum mode of operation for the motor and many other things which will allow the building of an experimental model in the future capable of reaching a speed of 400 km per hour.

The advantages of high-speed ground transport over the existing types are obvious. The following figures should suffice. Air and road_ transport burn three-fourths of all produced fuels, and the combustion process, naturally, affects the Earth's ecology. When an automobile runs 15 thousand kilometers, it takes in 4,350 kilogrammes of oxygen, "exhaling" 3,250 kg of carbon monoxide, 93 kg of poisonous hydrocarbons and 27 kg of nitrogen oxides. Moreover, airfields and motor roads occupy thousands of hectares of fertile land. It is easy to imagine what happens to our planet when all these modes of transport are developed at very high rates.

The future trains should be ecologically clean and noiseless. It has been estimated that the cost of introducing high-speed ground transport will be recouped three times faster than with the railways. This mode of transport can also substitute for aviation at distances shorter than 2000 km, connecting cities to airports (these-being the roads with the heaviest traffic) and this country's industrial centres.

The first magnetic suspension train is not yet in operation, but its principle has found a way into technology. Several years ago the designers at the St.-Petersburg railway institute installed a noiseless magnetic assembly line at the St.-Petersburg Svetlana amalgamation. Some polytechnical institutes have been conducting successful research on transporting melted metal with the help of a magnetic field.

The Sun's new 'trades'

Here is the latest news on the use of the energy of the Sun: "A plane crossed the British Channel on solar energy."

In the 15th century BC an organ was built into the statue of the Egyptian Pharaoh Amenophis III. As soon as the first rays of sunlight fell on the system of air-water chambers the stone idol began to sing. The singing pharaoh greeted sunrises for ages boggling the imagination of contemporaries. This is one of the ancient examples of the use of solar energy. The numerous evaporizers, that

The Solntse (Sun) research-production association has been set up in Turkmenia, not far from Ashkhabad, between the Karakum Desert and the foothills of the Kopet-Dag mountain range. The area has 250-300 sunny days a year on average.

Redzhep Bairamov, General Director of the association. Academician of the Turkmen Academy of Sciences, says:

"Every year the Sun sends to the Earth a stream of energy 10 times larger than the energy of all the fuel hidden inside the Earthy If we could manage to make use of only 5 per cent of solar energy, falling on a tenth of all the deserts in our country, then we would obtain some four billion kilowatts."

The scientists at the association are looking for ways to use solar energy. The bowl of the huge mirror concentrator of energy sparkles brilliantly at the, proving grounds.

The numerous evaporizers, that somewhat resemble conventional hothouses, standing nearby, avidly absorb the heat.

One of the laboratories is doing research into using solar energy to obtain super-pure metals, super-hard alloys and ideal semiconductors.

Another laboratory - of heliobiological installations - astounded me with figures. Chlorella, a unicellular alga, is used to fatten agricultural animals If it is regularly admixed to the animals' feed then their increase in weight goes up by 30 per cent! The cows increase their milk yield by about the same figure. The secret of this wonder seaweed is that it is composed of nearly 50 per cent of protein The first closed-type installation in our country for growing chlorella with the aid of solar energy is in operation at the institute.

And at the laboratory of heliohothouses, I was told that as it turns out, even such .a warmth-liking citrus fruit as the lemon can be grown in solar hothouses. The farm in Ashkhabad district has started building the first lemon-growing hothouse in the country. It will yield over 300,000 lemons per season.

Redzhep Bairamov says about one of the main trends in their work:

"Our country has over 35 million hectares of desert pastures. We propose to build autonomous heliocomplexes in deserts. A solar installation will be pumping water out of the wells, then desalinate it, if need be, to heat it and deliver it to the hothouses and homes. People can live in cities, partaking of all the boons of civilization and go to the desert to work - to graze the cattle."

The Sun has many "trades" today. One of the more interesting of them is connected with medicine. Two heliocentres for treatment of adults and children have been set up in the capital of Kazakhstan. They are based on systems of mirrors which concentrare sunlight. Children's doctors are especially using the heliocentres. They have now at their disposal a reflector made of 200 small mirrors It concentrates the rays into a spot of Sight a sort of sunbeam which moves over the body of the patient securing a curative heating which goes deeper than other methods.

As the Kazakh doctors have established that such a "medicine" made of solar beams helps to cure bronchial asthma, bronchitis and some other diseases quickly.

Our country holds the priority in many uses of solar energy. Irradiation of plant seeds and treatment of different human diseases with the aid of pulses of concentrated sunlight are not as yet being done in any other country except ours.

The Sun has started to be used also to heat dwellings. For example, the Hotel Sport in Simferopol supplies hot water to its guests in the summer by using solar energy. A two-storied block of flats in Odessa also received the same heat. Daghestan has one family "heliohouses". An experimental complex of three multistoried houses is being built in Ashkhabad, and in Uzbekistan construction has begun of 40 four-storied blocks of flats and 26 kindergartens for 320 children each. This is but the beginning. In time solar energy devices will become as common as electric teapots or heaters.

The conquest of tungsten

In the face of the onslaught of daring research, tungsten, the metal which metallurgists could not place under their command for a long time, was not able to hold out. A tungsten ingot has now been smelted in the Monokristall plant at the A. Baikov Metallurgical Institute of the Russian Academy of Sciences.

A diverse biography of taming molybdenum, tantalum, tungsten and rhenium' this "elite" of metals in Mendeleyev's table, contains many much-talked-of sensations. The method of sintering metal powders was considered a great event in its day. "Sticking together" took place on the verge of melting. Metal powder sintering was followed by electron-beam technology. Under the action of powerful electron beams the possibiity presented itself to obtain cast articles. However, even these novelties could not solve many problems. In particular, -the melting process proceeded comparatively slowly, and the required purity of ingots could not be attained. Furthermore, the size of ready articles was very limited...

Only when the researchers' attention was fixed on the plasma, a high-temperature "atmosphere" of electrically charged gases, did vast perspectives open up for the metallurgists.

An impressive-looking machine stands before us. It has concentrated the achievements of science and engineering. A single complex combines a melting unit and an intricate system of monitoring and control.

The experimental start-up of the plant is about to begin. The engineer-operator fills the hopper with tungsten powder and presses the keys on the control desk. The display screen flashes up, and the image of a plasma starts to sparkle.

The melting point of tungsten is nearly 4,000° C. And in the thick of the electric arc flux the temperature is 10-12 thousand degrees... Under the action of such a fantastic heat tungsten starts to melt, settling in the form of a super-hot drizzling rain on a starting matrix of the future form of the article. The display screen shows how the metal is building up, layer by layer. According to the "pattern" predetermined by the operator, tungsten precisely follows the required form.

In the specialists' opinion, this plant has good prospects for producing structural materials. Using powders, it is possible to easily vary the composition of a charge and obtain complex monocrystals of various materials with predetermined physical and mechanical properties. And the high temperature of the arc ensures complete sterility of metals and their alloys, which substantially improves the quality of the articles.

Insulator turns into superconductor

Having used ultrahigh pressures and critically low temperatures, scientists at the Institute of High Pressures of the Russian Academy of Sciences have managed to effect such a unique transformation as converting a sulphur insulator into a superconductor...

Superconductivity, at which a conductor completely lacks resistance to electric current,was discovered more than 70 years ago. This phenomenon occurs at temperatures around -273°C.

Present-day electronic, electrotechnical apparatuses, instruments and machines have been developed, operating on superconductors under conditions of low temperatures. Among them are radio-receiving devices for detecting weak signals arriving from the depths of outer space, highly efficient powerful, and yet small, current generators, transformers and cables.

The equipment that uses superconductors is expensive and is not available for users at large. That is why scientists are looking for materials which would become superconducting at a temperature of for example, liquid hydrogen, which is -252°C, or liquid nitrogen, which is -196^{U}C. Sulphur has been quite unexpectedly found among the superconducting materials.

Yevgeny Yakovlev, D. Sc. (Physics and Mathematics), head of the Institute of High Pressures, who is in charge of research on the superconductivity of sulphur, says:

"The main unit of our installation is a high-pressure chamber. It contains two anvils of synthetic polycrystalline diamond, 'carbonado' or black diamond. The surface of one anvil is flat, whereas the other one is shaped as a cone. When compressed, the anvil point develops a pressure of half a million atmospheres! Under such conditions sulphur converts to a 'metallic' formation. 'Metallic sulphur", cooled by liquid helium, acquires superconducting properties at a temperature of -269"C.

"Experiments are being continued and have so far yielded interesting results. Sulphur has increased the temperature of conversion into a superconducting material to -242°C.

"Up to now a champion in high-temperature superconductivity has been a hiobium-to-germanium compound. Its conversion temperature into a superconducting state was -250°C. Now the leadership has passed over to sulphur.

Metals from the sea

A floating Installation, developed at the Institute of Oceanology of the Russian Academy of Sciences, will start extracting rare chemical elements from seawater off the Black Sea coast, this spring. The installation weighs four tons. It will be a prototype of the semi-commercial floating factories that will start operating within the next few years.

Even though Russia firmly holds first piece in the world for reserves of many minerals on land, our scientists have been seeking for a long time for methods to extract such elements as uranium, lithium, silver, gold, cesium and germanium from the sea.

Only several years ago the prevalent opinion was that extraction of precious metals from the sea could start to be economical only in the distant future. But just today I saw a test tube with a heavy black powder in it—the first grammes of uranium salts, the nuclear fuel for atomic power plants. This is the first tangible result of the colossal work performed by a group of scientists led by Pavel Novikov, Cand. Sc. {Engin.}, at the Institute of Oceanology,

Using free energy.

Calculations showed that the existing world prices on rare metals would make the cost of the energy expenditure on their extraction prohibitive. It is enough to say that 1,000 cu m of seawater contain about three grammes of uranium. Therefore, if we wish to get a ton of uranium, we must pump 300,000,000 cu m of seawater through the installation. So what is the economically acceptable method proposed by our specialists?

"When we were searching for a profitable method we immediately discarded the idea of pumping stations," Pavel Novikov says, "In our method the ocean itself acts as a 'pump, i.e., we capitalize on the free energy of the tides and currents. Our installations are designed to periodically 'drown' and 'surface' in autonomous conditions, without man's participation or the expenditure of energy. They go through the water, rising and falling and we only have to collect the metals they 'catch'."

In a corner of the laboratory I saw several frames, the size of a desk drawer, covered at both ends by meshing.

"The first grammes of metal were obtained from seawater, in these laboratory, devices, without the use of energy," Puvel

Novikov explained. "Inside you can see pieces of ion-exchange resin. It actively absorbs the salts of heavy metals from the solution and is now widely used in desalination installations,"

Following nature.

This process resembles what takes place in nature, .when marine plants and animals accumulate within their organism elements in much greater amounts than they are contained in the environment. For example, the Iaminaria seaweed contains 100,000 times more iodine than the seawater in which it grows; the conventional jellyfish "collects" zink, tin and lead; the octopus—copper, and the ascidia—vanadium.

No wonder scientists call seawater the "foremost comprehensive ore". That is perfectly correct. Nearly all the chemical elements known to man have been discovered in the seas. The rare metals offer special interest, because they are vital for electronics, transistorised instrument production, the making of photo cells, plastic lubricants, special glass, heat resistant ceramics, fluorescent lamps, etc.

But what effect could the. extraction of rare metals by the too have on the ecology of the ocean? Mankind has already encountered the harm intensive extraction of minerals on land has produced on nature. Could the same thing be repeated?

Neptune’s storages are inexhaustible.

"It is rather difficult to provide a simple answer to this," Pavel Novikov says. "But Boris Laskorin, a Soviet Academician, maintains that natural energy-using floating installations with our "sieves" of iop-exchange resins will not harm nature, because they are inert in themselves and produce no harmful wastes. Even more than that. They will help utilize the saturated solutions dumped into the sea by desalination stations and chemical plants.

"In the future, the extraction of elements from seawater will, apparently, turn out to be the biologically cleanest production. There is no need for laying railway tracks to these reserves. They won't produce the slag heaps inevitable in mineral extraction on land. And there is also no need for the energy required for digging up huge amounts of earth."

"And won't the ocean ever get exhausted?"

"I don't think it ever Will divers and underwater volcanoes are constantly replenishing the seas' stores, they are virtually inexhaustible. So in his respect mankind has nothing to worry about."

Trains without wheels

Mechanical pumps cannot be used to pump molten metals because most liquid metals are so highly corrosive that any material they meet is "eaten away" in a matter of hours. Besides, operating such pumps makes _the staff's working conditions both arduous and damaging to health.

However, there are natural forces which can set any molten metal into motion without electric pumps. These force appear in the metal itself when it is exposed to electromagnetic fields, and are the result of direct conversion of electrical energy into mechanical. Magnetohydrodynamic (MHD) machines use these forces to move, mix and measure out molten metal.

Our scientists have made a considerable contribution to the theory of MHD machines. Academician Alexander Voldek, of the Russian Academy of Sciences and Professor at the Polytechnical Institute, founded this theory and the school of research into the operation of molten-metal machines. His fundamental research has considerably influenced the development of the MHD technology both in this country and abroad. His basic theses still attract ' many research institutes, colleges, universities, and industries. For example, major projects in" the theory and development of an automated MHD drive, such as an MHD pump controlled by a source of power and an automatic control system, are carried out by scientists from the Polytechnical Institute's Department of Electric Drives.

MHD drives have made it possible to pump molten metals along pipes, with their rate of flow and pressure being controlled at the same time. The creation of this type of power equipment has enabled new "production processes to be introduced on a large scale in at least four industries - nuclear power engineering, metallurgy, foundry and in the chemical industry. For example, modern nuclear reactors can use alkaline metals, Such as a sodium-potassium alloy, as heat transfer agents. This alloy carries heat better than other liquids. Besides, these metals are. light, and are good conductors of electricity. They are used in MHD installations to remove heat from power reactors.

In fact, the MHD drive has the properties of both an electrical machine and hydraulic installation, which provides a high degree of controllability. A direct electromagnetic power effect has made possible a basically new installation for casting molten metals in metallurgy. For example, a conventional foundry automatic machine or robot often imitates a human foundryman, with the metal being poured into a mould by means of a ladle. However, this ancient method has its drawbacks. It destroys the oxide film so that the surface of the molten metal in the ladle becomes oxidized when exposed to air, whereas when using the MHD drive as a metal carrier, the oxidation and burning of molten meta! can be completely eliminated.

Besides, our research into the MHD drive theory is being used to solve a number of problems in the design of high-speed ground transport without wheels, in the machine-tool industry and in robotics. Our laboratory has already designed small linear motors for manipulators which feed sheet metal for cutting by shears. Such motors have also been fitted to turntables for X-raying welded seams in thin-walled metal cylinders, to turning foundry installations and to other machines.

The Caspian Sea surprises

The Caspian Sea, the largest inland sea in the world, has been living at a rhythm of changes thus far unclear to us. The sea had been lowering its level for the last 400 years but quite suddenly started to raise it five years ago. If we consider that one year before that the Caspian Sea was at its lowest level for the historically known period, the mistrust towards this sharp change becomes understandable. How long will the new process last? Will it be followed by a new lowering? Can it be just an incidental, short jump in the level? This happened before, not so long ago.

These are not just questions for questions' sake. The Caspian shore is densely populated. The rising level means rising subsoil saltwater, deadly to vegetation, corroding long-established underground communication lines and foundations, and forcing restructuring of the sea gas- and oil-rigs. There are also other innumerable damages.

Permanent instrument observation of the Caspian Sea level has been conducted since the 1830s. All throughout the period, the sea's level has been greatly oscillating, dropping as much as 3.5 metres by 1967. This was seemingly followed by a stabilization, while small lowerings were taking place just the same. As a result, by 1977 the sea's level was 29 metres below that of the World Ocean.

It was expected that the lowering trend would prevail over the next century, perhaps even two. More "exact" calculations were attempted, too. For example, it was expected that by 1965 the sea's level would drop two to three metres from the 1950 mark. That was the time of the most worrysome hypotheses about the fate of the entire Caspian basin. One had to possess the optimism of Academician L. S. Berg to claim: "Continuous lowering of the Caspian Sea level cannot have gone on for all time. The sea oscillations have had their periodicities, and the present lowering of the sea's level is one of the episodes which has taken place over the past two millennia: its level lowered only to rise again."

The "episode" is over. But the same questions remain: what happens to the sea? Why and for how long will the new rising continue? It is very difficult to live near water which alternately recedes and then tries to flood everything lying around it, playing with shallows, depths, and islands, turning them into peninsulas or destroying them altogether.

Here is what Nikolai Goptarev, Cand. Sc. (Geography), head of the sea\hydrology laboratory at the Institute of Geography who devoted many years to the study of the Caspian sea, says: "Periodicity in the change of the sea's level does exist. But it is not strict enough to make a rule out of it. The Caspian Sea is not linked to the World Ocean. Its water represents the water of the rivers that flow into it. Hence, the sea is sensitive to what happens in the basins of these rivers.

"In determining the level of the Caspian Sea, our laboratory proceeds from the assumption that the climatic conditions in the Caspian basin will not have changed considerably over the next 10 to 20 years. This means the rivers' flow will be at approximately the same level as will precipitation and evaporation from the surface of the sea. What remains to be taken into account is the quantity of water which will be taken from the rivers, for irrigation. Now it is 40 cubic kilometres and it may reach 80 cubic kilometres by the year 2010.

New 'trades' of the Sun

In the Turkmenian capital of Ashkhabad 25 state automobile inspectors have been given portable solar electric stations. Under the cover of a transparent plastic panel, semiconductors can transform not only the radiation of the Sun, but the Moon at night and even street lights into electric energy. The Sun and the Moon both feed the "pocket" electric station, and recharge it for two-shift operations at once. The scope of the radio station operation, which used to be limited by the small capacity of accumulator batteries, is now considerably greater.

"Scientists in many countries are working on the use of solar energy in the most varied spheres of human activity," says B. 'Bazarov, Cand. Sc. (Physics and Mathematics), director of the Turkmen heliolaboratory. "As we know, the Sun's radiation can be directly transformed into electric current by solar elements. This process is called 'photoelectric'. It has very many advantages. An immediate transformation takes place of direct and also the diffused light of the Sun, the Moon and other sources of light. The weight of the elements is not great - modules of the most varied sizes can be assembled from them. Such modules can be easily mounted in a portable radio station and can also feed a large electric station. The elements do not suffer from wear and tear, and the energy sources working on these elements do not pollute the environment.

"In our laboratory we have carried out dozens of experiments for using solar energy in the economy and everyday life.

"A miniature solar electric station was mounted on the roof of a minibus to supply energy to the minibus engine. Forty solar elements for directly transforming Sun radiation into electricity were installed on a distant pasture. The electric current they generate moves the pump which provides water for the animals. The bluish belt of solar batteries around the dome of a yurt (herdsmen's tent house) generate electric energy for house-hold needs. Our laboratory staff are working on another solar electric station which will feed the ultrashort wave radio-relay communication line along the gas pipeline Central Asia-Centre. Photogenerators are advisable for many autonomous small-capacity ground consumers - navigational instruments, automatic meteorological-stations, and radio buoys. In our country, where there are many sunny days each year, the Sun, this eternal source of energy, will certainly be used more and more. Of course, many problems still stand in the way of using solar energy.

"It would be very good if we could regulate electric energy: accumulate it when there is a surplus for times when there is a shortage. Many researchers are working on the problem of using hydrogen as the cheapest accumulator. For this purpose water is decomposed into oxygen and hydrogen with the help of electric energy. So whenever necessary the hydrogen can again be transformed into electric energy. We believe this a very promising prospect which is certainly worth the effort."

Power storage and transmission: new research

If we knew how to transport considerable power flows over superlong distances, this would be tantamount to building many new power stations.

Russian, for example, which spans eleven time zones, would be able to connect power sources alternately to eastern - or western districts. If the stations operated with a permanent load most of the twenty-four hours, power production costs would go down.

Power transmission from Siberia to the European part of the country, where most of the fuel and hydrorc-sources are, is extremely difficult at present. But our engineers are already solving certain problems of long-distance power transmission. For example, a 2400-km-long and nearly 6-milIion-kw power transmission line is being built between Ekibastuz (northern Kazakhstan) and the Centre. Still longer and more powerful lines are in the offing. Since the capacity of the aerial power transmission lines reaches its technological limit, it is suggested that several parallel lines be built between the eastern and western districts.

At the same time, research laboratories are looking for principally new methods of power transmission which would allow carrying many millions of kilowatts along the same line. It is desirable, of course, that the new lines be less expensive, take less area, and be as safe and reliable as the traditional ones.

The possibility of building gas-insulated lines is of great interest. They consist of two concentric pipes with special compressed insulation gas between them. Like gas pipelines, such lines can be laid underground or on the surface.

Besides, electricity can be transmitted along conductors consisting of a special alloy and cooled to a temperature close to absolute zero (about 4° Kelvin). Current actually flows without losses in such superconductors, event if its density is thousands of times more than the density of current in conventional copper conductors. The main difficulty in building power transmission lines on the basis of superconductors consists in maintaining the low temperature along the entire route. This requires a high vacuum and thorough heat insulation.

Not so long ago they started research on power transmission by one more basically new method: a beam of electrons flying in a vacuum pipe at near-light velocity. The possibility of converting electric energy into particles' kinetic energy and vice versa has been known for a long time. There exist many methods of particle acceleration. But only in recent years has the development of acceleration technology reached a level when a beam of average capacity, dozens of millions of kilowatts, and the corresponding tracks for carrying them no longer seem fantastic.

The basic scheme of the new line can be made as follows; electric-kinetic power converter (accelerator), the pipeline carrying the electron flow, and the kinetic-electric energy converter (recuperator).

A vacuumized 0.5-1.0 m pipe can probably serve to transmit an energy of dozens of millions of kilowatts. But all the facets of problems with such Sines have to be researched. For example, the existing accelerators do not provide the necessary parameters of the beam. Taking known requisites, still lacking are new particles accelerators, new line design, and learning how to focus the beam in the vacuum pipe.

Other ideas for transmission of electricity may also appear. Besides the above described suggestions, superhigh-frequency radiation and some other ways are now under consideration.

Alloy suppresses noise

Russian scientists have made a valuable contribution to the study and prevention of industrial and everyday noise.

Control of noise sources is one of the most important tasks in the ecological problem of nature protection," says Professor Mikhail Drits, head of a laboratory in the Baikov Metallurgical Institute of the Russian Academy of Sciences.

Why do machines produce noise? While in operation vibrations arise in their units, which bring about elastic wave-carriers of energy. And if the units oscillate in the resonance mode, they increase to such an extent that the units cannot withstand them, and are ruined. Researchers, in discovering the mysteries of vibration activity of materials, have also revealed ways of fighting it. It has been established that in the effects of exciting vibrations in materials the called reversible variations may also arise. They absorb the energy of elastic waves. And this is just what results in dampening oscillations. The material ceases to vibrate and thus to make a sound. The disclosure of this physical phenomenon has formed the basis for the development of vibration-dampening alloys.

Together with the researchers of our laboratory," Professor Drits pointed out, research associates from Other organizations of the country have taken an active part in the development of vibration-dampening alloys. It helps us speed up fund mental investigations and adoption of the results of scientific work in industry."

At present vibration dampening alloys have been obtained based on light and heavy metals. We recommend that noiseless alloys be used first and foremost for bed frames and units of machines, hover craft, aircraft, rotor blades and shafts, and textile machinery among other items

The composition of vibration dampening alloys includes generally available metals. Thus, on the basis of magnesium, manganese, iron titanium and some other metals it is possible to create alloys capable of dampening vibrations. Alloys based on manganese with additions of some other metals should be particularly distinguished. They can be used for making parts of any predetermined shape. They are easily machined alloys which have been used for making lots of gear wheels, springs, electric machine parts and drilling equipment.

A polymeric electric motor?

When chemists have synthesized current-conducting polymers, an idea to use them in electrical engineering has sprung up then and there.

What has served as a basis for obtaining a new material? The simplest hydrocarbon, acetylene, which is a gaseous substance having high heat conductivity. This makes it possible to widely use it as a fuel in autogenous welding and cutting of metals.

Recently the scientists of the Institute of Chemical Physics of the Russian Academy of Sciences have discovered an effect of acetylene polymerization. From a gas state acetylene has been converted into a liquid, and then into a solid substance. Thus, a polyacetylene has been obtained, a new synthetic compound which is said to have a great future in engineering. Today it has served as a basis for creating the whole number of compounds having an electric conductivity.

At the Institute laboratory a brush-electrode has been developed for feeding current to an electric motor. So far brushes have been made from graphite. They have worn out quickly, causing sparking and becoming sources of radio interference. New polyacetylene brushes will serve ten times as long. They possess other advantages as well. Thus, due to high electric conductivity, hardness and a smooth surface they eliminate sparking.

Testing of slip-ring brushes in electric motors of trolleybuses has shown that they serve without wear twelve times as long as ordinary graphite brushes.

How do the scientists imagine the future of the new current-conducting material in making electric motors?

A core of a conductor will be made from a current-conducting polymer, and its external cover from an insulating polymer. A stator magnetic core, now made from a special-grade steel, is next in turn.

‘Netting’ for metals

Knowledgeable people say that there is no such thing as pollution – simply good substances finding their way into the wrong environment, such as heavy metals in factory waste. If the metal is extracted, it no longer becomes a pollutant, but a very valuable industrial material. So it all comes down to extraction. Moscow University chemists found a way to do it.

Traditional technologies—both physical and chemical—are unpracticable in instances when not saturated, but highly diluted solutions are being dealt with. Of course, there are technologies of extraction for small concentrations, but they are excellent in the laboratory and extravagantly expensive at a factory. If it is platinum to be extracted, the cost might not matter so much. But what if it is not a precious metal?

Naturally, the metal should not be left in the waste to polute the environment, and squander many.

One might think that if water with the substances is passed through a sorbent, the metal would be extracted. But In fact, one comes up against a host of problems. First, there has to be a selective sorbent. Second, it has to remain intact after the passage of a stream of water and third, It should not be exotic, but rather easily available. Moscow University associates hit on silicon-based mineral polymers.

These are not in short supply, « they have long been used in industry It was chemically attach to the surface of one of them a multitude of different substances which form a bond-will a certain metal.

Led by Professor S. Viktorova, the team synthesized a group of these substances on a mineral carrier. As it turned out, many may be commercially used. Experiments indicated that such mineral sorbents can extract valuable metals like gold, copper, and cobalt from solutions. And unlike previous treatment systems, in which metal extraction using ion exchange resins took hours process takes place in seconds-minutes if necessary.

The important feature is that ihe sorbent can be used over and over again after the metal is "flushed" from it.

Studies of substances which have been chemically attached to the mineral carriers are being conducted at several research centres including those in Siberia. It can even be said that there science associated with those materials. Naturally, their qualities do not confine them to be used only to extract valuable metals from diluted solutions out that is another topic.

As a matter of fact, optimistic scientists believe that in time the product-a sort of a chemical net to catch metals-will be used to extract valuable substances directly from seawater.

As far as today is concerned the new materials are being commercially produced, "and equally important, they are already being used to extract precious and rare metals from industrial waste and other solutions–those very metals which m water are considered pollutants.

Bacteria in mining and smelting

Some metals which are inedible for the majority of living creatures are a treat for certain microorganisms. For example, if we "serve" them zinc, copper or gold compounds, we can easily see after some time that a considerable portion of the metal has acquired a state which is acceptable for further processing. The process is most effective in cases when the traditional methods of metal extraction are unfeasible.

Waste-free production.

Virtually every mining enterprise breeds huge dumps of so-called waste rock. The waste, however, contains tons and tons of valuable raw material. Sometimes the ore Contains non-ferrous metals in percentages too small for the available enrichment methods, or the metal is found in combinations not desirable for these methods.

The researchers at the Institute of Chemistry attached to the Russian Academy of Sciences have been the first to employ agents invisible to the naked eye in order to extract copper at the waste dump in one of Tajikistan's mining enterprises. After a cycle of laboratory experiments, the nutrient medium with bacteria was introduced into the waste rock. The bacteria have extracted virtually all the copper from the dump by converting it into compounds suitable for further processing. Researchers suggest using similar methods, for producing antimony and tin

Not infrequently, industrial enterprises' waste water contains various concentrations of sulphate salts. It is possible to make an industrial plant for saturating water with bacteria whose living activity can cause the formation of hydrogen sulphide. The gas produced with the help of light and catalysts (this process is known) disintegrates into sulphur and hydrogen. Industry is in constantly growing need of sulphur. The importance of obtaining cheap hydrogen in large quantities is evident because Russia and other countries are investigating the possibility of using it as an energy source.

Chemical bacteria technology for producing non-ferrous metals is already finding ever wider usage in industry today. About 20 per cent of the world's copper production is achieved with the help of microorganisms.

Some other microorganisms may prove to be more promising than bacteria in the production of non-ferrous metals. Common mushrooms, for example.

Not by waste alone.

We have developed a laboratory method for extracting arsenic from waste water. The known purification technologies have a number of complexities, like having to convert arsenic into difficultly soluble compounds and thoroughly bury them. The fungi planted in the waste waters convert the arsenic into a gaseous state. The subsequent process of arsenic extraction, which is also needed in a number of industries, causes no problems.

There are reasons to believe that simpler fungi will also help extract other valuable chemical elements from the waste.

There is no doubt that this method will soon be employed not only for putting waste to productive use, but also for extracting non-ferrous metals from low-percentage ores. One does not have to be extremely imaginative today to visualize wells being bored to the ore seams, some of them pumping nutrient solution with microorganisms, others taking out the metal-saturated solution to industrial plants for final processing. Those will be ecologically pure industries doing without hard and hazardous miners' work, and without huge energy consumption.

This tempting picture is very approximate, since the search has just been started. We do not yet know the capabilities of many microorganisms. If we evoke the present-day achievements in genetics which open the prospect of manufacturing microorganisms with preset desirable properties, then, we can imagine a biotechnology allowing us to obtain not just metal but, say, its strictly definite isotope.

The omnipresent sputniks

Every year nearly a hundred spacecraft of different purposes are launched from the cosmodromes. Most of them are man-made satellites of the Earth of the Kosmos series. The first Kosmos was put into orbit 50 years ego. Now their number is approaching a thousand and a half. They tackie the most diverse tasks — from studying near space to staging medical and biological, and technological experiments.

High precision for seagoing ships.

As present, a satellite navigation, system, consisting of several identical vehicles, is being created on the basis of the Kosmos series. Each of them is a space navigation beacon, using which seagoing vessels can, with a high degree of precision, point of the world ocean, regardless of the weather condition.

The importance of this system is self-evident. According to calculations, the data received from navigation satellites make it possible to cut the duration of transoceanic cruises by 45 minutes a day on the average. Considering the present-day .scale of the seagoing fleet — approximately 65,000 vessels, not to mention fishing and pleasure boats—this annually gives a saving to the tune of hundreds of millions of dollars.

It; addition, location of the ship's position with the help of a satellite ensures a considerably higher degree of precision than with the use of traditional landmarks. This means that it will be possible to avoid manv gigantic disasters, like the wreck of the Liberian tanker at the Tobago Island, when 300,000 tons of oil poured out into the sea. An oil slick of 230,000 tons was precipitated on the French coast by the American *Amoco Cadis*, Now it is difficult even to predict all possible consequences of these hazards in connection with environmental pollution. After all, it takes at least 7-10 years to restore the natural biological balance only after one such catastrophe. According to UN estimates, already now the annual biological productivity of the world ocean has dropped by more than 20 million tons of biomass compared to what it used to be before the beginning of intensive pollution. How these processes will continue to develop is yet to be found out. An important part in the solution of this problem is allotted to the self-same Kosmos satellites.

These space vehicles have been instrumental in carrying out the first experiments in collecting comprehensive oceanographic information.

These experiments marked the beginning of the systems of operative global measuring from outer space of the characteristics of the ocean, which are necessary, in particular, for the effective solution of problems of oceanic fishing, and laid the foundations for a regular space service of oceanologic studies.

A factor determining the climate.

We now know that the main factor determining the climate of our Earth is the Sun. However, it is essential to know how much solar energy comes to the Earth atmosphere, how it is absorbed by different layers of the air, and how much of it is emitted beck into outer space. Another cardinal question is the study of the heat and moisture exchange between the oceans and mainlands through the atmosphere.

The information obtained from the Kosmos satellites produced a number of fundamentally new concepts about the atmosphere and the properties of our planet. It has been found, for instance, that the atmosphere stretches not within the limits of a hundred kilometres, as previously believed, but to several thousand kilometres from the surface of the Earth. Heated by the short-wave solar radiation, the upper atmosphere of the Earth "breathes" — its height above the surface of the Earth tends repeatedly to increase and diminish. The changes depend on the time of the day and the year, and also on the state of solar activity.

For the meteorological service, especially for making longterm forecasts, there is a need for temperature charts of the world ocean surface, with errors not exceeding two degrees. The point is that the heat accumulated in the equatorial areas of the ocean determines the impact of powerful currents, such as the Gulf Stream, on the formation of the weather and climate in the European part. For instance, in February 1980, in the Gulf Stream origination zone, the temperature of the ocean was found to be 1.5-2° lower than the average annual norm. A month and a half or two months later, the satellites marked this anomaly already to the east of Newfoundland. Then the cold spell came to the European waters, and, as a result, cold and rain swept across Europe. The "reverberations" of what was happening in the tropics are still heard", a season or even half a year later, on the territory of our country.

The Kosmos-243, -384 and others were used for the first time to test new radiophysical methods of remote-control determination of the parameters of the atmosphere, ocean and the surface of the mainland. They made it possible to study the properties of the environment in any weather with the help of artificial satellites. Subsequently, these methods were used in the Meteor system.

Long-range communication.

No less is the contribution of the Kosmos series to the creation of a system of long-range space communication in our country. They helped size up the effectiveness of different means for long-distance radio-TV communication establish the most advantageous parameters of satellites' orbits, obtain information on the spread of radio-waves in near space, and find optimal conditions for work of satellite-borne and other equipment.

For the first time the entire surface of the Earth was subjected to magnetic survey, and it was done practically at one and the same time.

Fire giving birth to electricity

In September Moscow will host the Eighth International Conference on MHD Electric Power Generation. We publish an article about research in this field.

On March 28 1971, the world's first pilot-commercial plant for direct eon version of thermal into electric energy by the magnetohydrodynamic method (MHD) produced its first electricity at 23:07 p.m.

Back in the 19th century the English physicist William Thomson performed an experiment. From either hank of the Thames, he suspended copper electrodes into the water, connected by an isolated cable and tested the circuit thus created with an ammeter. During high tide, current appeared in the circuit.

The experiment demonstrated once again that an electromotive force appears in a conductor when it crosses a magnetic field. In the above-described experiment, the conductor was provided by the salty, consequently electrically conductive, ocean water which the tide brought to the river Crossing the earth's magnetic field, it created electric energy, as registered by the experimentor's instrument.

But a conductor may also be provided by highly heated gas moving swiftly in an electric field, its atoms losing a great quantity of electrons which carry the current m plasma. This is elementary; electric current appears in a flame (electrically conductive) placed between two poles of a magnet it would seem that an apparently simple method of obtaining electric energy from such a heat-electricity system (not using boilers, turbines, or common electric generators) should long since have been used by man in the building of electric machines. But, as it often happens, years, decades, and sometimes even centuries lie between a scientific idea and its materialization.

That was the case with the idea of direct conversion of heat energy into electric energy. Gas becomes electrically conductive only when it is highly healed to temperatures ranging from 2.500' to 2,600 C. But equipment capable of withstanding such a barrage of white-hot gas (plasma), whose temperature exceeds the melting point of steel by almost 1.5 times, has appeared only in our age of space and rocket technology Only now has it become possible to obtain superhigh-temperature materials and structures withstanding high temperatures, to control very complex technological processes and consequently, to build power plants for directly converting thermal energy into electric energy by the MHD method The plants are railed MHD generators

I am now in the machine room of the world's first such power station, one which generates electricity directs from heat. It has been built through the efforts of scientists and workers in a Moscow suburb. The power station's unique equipment has also been made completely at factories.

Almost 35 years have passed since a small-sized MHD generator was built at the Institute of High Temperatures of the academy of Sciences by a group led by Academician V. Kirillin and Academician A. Sheindlin. It consisted of a magnet, some plasma between its poles, and electrodes sunken into it Then a small-capacity combined experimental plant, named U-02 was made at an old power station in Moscow It was meant for research and testing of units for future power stations. Next, they commissioned a pilot-commercial plant with a 20,400-kilowatt MHD generator. Everything is unusual here, everything differs from the steam-turbine power station. There arc no rotating electric generator turbine units.

"The main, pivotal element of the plant, says Sergei Pishchikov, deputy director of the Institute of High Temperatures, "is represented by a huge magnet with a channel inside it, through which a jet of low-temperature' plasma passes, that is, a jet of incandescent gas. Current originates in the plasma and is taken from the channel's side walls.

“Creating plasma is a complicated affair. When gas burns in cold air it cannot exceed 1,800°C, so it is preliminarily heated or enriched with oxygen in order to reach the required temperature.

"For this aim," explains Pishchikov, "we use high-temperature air-heaters (Cowper stoves). They heat the air to 1,200°C, after which it enters a chamber where the temperature of the natural gas combustion products rises to 2,500°C. The mean descent gas is accelerated in the nozzle and arrives in the MHD generator channel at bullet velocity. "As is well known, electric conduction rises along with the gas electron concentration. Gas ionization is raised by means of an additive - potash, which is introduced into the combustion chamber in insignificant quantities. Influenced here by the high temperature, the potash disintegrates into potassium and carbon dioxide Potassium atoms"

The heated and highly ionized gas (plasma) darts along the 5-metre long channel of the MHD generator, itself a powerful magnet. Current is created in the inside plasma and is tapped by the electrodes built into the channel's side walls.

"The gas temperature at the Channel outlet is still high, about 2,200°C. How can the heat be used? At a conventional station the combustion product temperature is 1.800°C, so the MHD generator gas can be used for producing electric energy by the steam-turbine method. The singularity of the MHD generator consists also in its operating in link with a conventional thermal power plant.

"We should also mention, "Pishchikov goes on, "that part of the heat is used to heat the air for the initial stage of the MHD generator operation, while the ionizing additive is taken out and re-used.

"Now consider the advantages of the new method of obtaining electric power. At steam-turbine stations, we obtain electricity as a result of triple conversion: a fuel's latent chemical energy is first turned into thermal energy, the thermal energy, into mechanical energy (steam rotates the turbine and the generator rotor), then mechanical energy is converted into electric energy.

"The MHD generators have no rotating units, allowing the temperature of the working medium (gas) to be increased. We know from thermodynamics: the higher the working medium temperature is the more-efficient any thermal machine be comes.

"Observe the following about a conventional power station. The fuel combustion product temperature is 1,800°C, while that of the steam is between 500° and 550°C. This means that a considerable quantity of energy is wasted when heat is supplied to the steam.

The highest efficiency for the modern steam-turbine stations is 40 per cent. So far, designers cannot obtain higher efficiency in the thermal power plants, nor are they likely to achieve more in the future. In the MHD generators, where the combustion products themselves operate, the electric power plant's efficiency goes up to 55-60 per cent. The fuel consumption is thus brought down. In this country, where thermal power stations account for about 80 per cent of all the power stations, use of MHD generators will allow savings of millions of tons of fuel.

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