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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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Development of Metalworking Industries in Developing Countries

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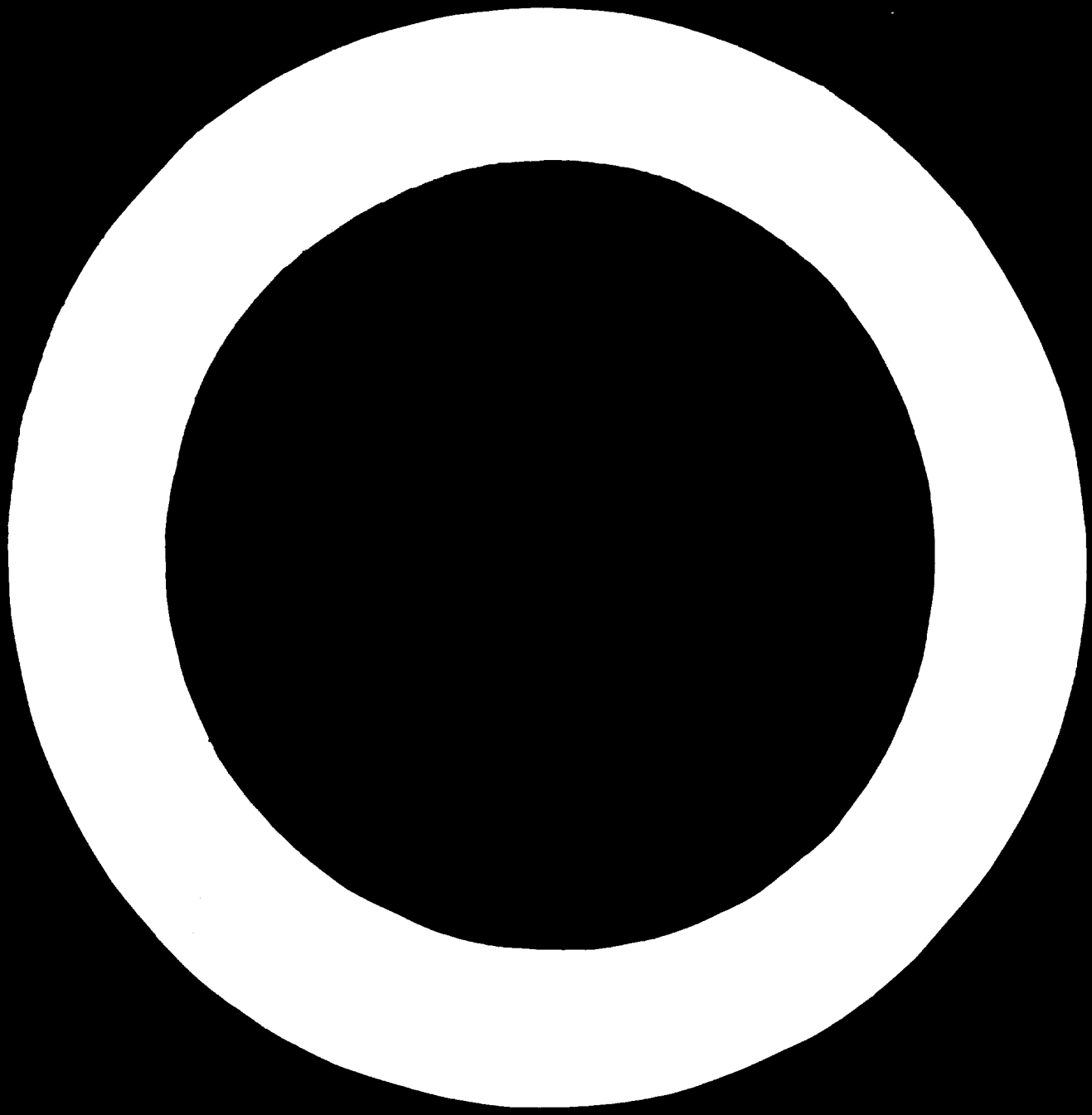

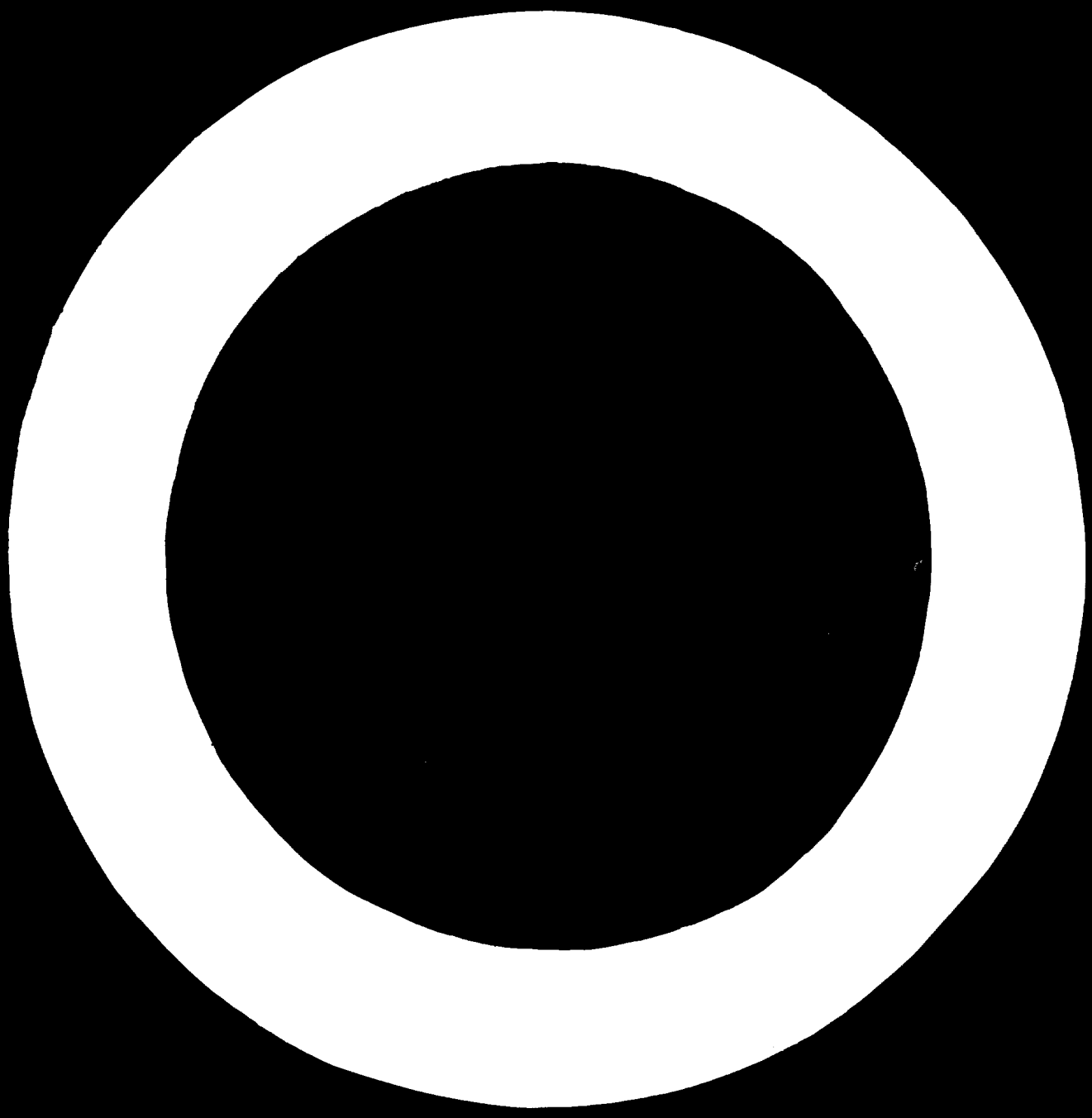

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BASIC PRINCIPLES OF TRAINING ENGINEERING AND TECHNICAL SPECIALISTS FOR THE METALWORKING INDUSTRY

V. A. Arshinov, Moscow Machine-tool Building and Tool-making Institute, Moscow, Union of Soviet Socialist Republics

Progress in any branch of science and technology as well as efficient use of scientific discoveries for the benefit of society, depends mostly on the availability of engineering, technical and scientific specialists. The higher the quality of training of the specialists and the greater the number of high-rated personnel working in the industry and in the research and scientific agencies, the larger the output of products required for the welfare and further progress of society.

Metalworking is essentially the most important technological process as, for today and evidently for the next decades, metals are and will be the main materials used for manufacturing a large variety of machines invented by the human being. That is why considerable attention is being paid to training engineering and technical specialists for the metalworking industry.

Metalworking, i.e. manufacturing of various components of machines, is accomplished mainly by casting, forging, stamping, welding and cutting as well as by electrophysical and electrochemical methods. This report deals mainly with the training of engineering and technical specialists for metal cutting.

The process of metal cutting is effected, on the metal-cutting machine, with the aid of metal-cutting tools. Metal cutting is a complicated process. It is accompanied by large strains and loads, friction, heat liberation, age hardening and wear of the cutting tools. The engineer engaged in this process should be well trained for designing metal-cutting machines and tools, for manufacturing these machines and tools, and for their rational use for production of the elements required in making some other machines. The ever-growing requirements for efficiency and accuracy of the metal-cutting machines face the engineer with the necessity of having a thorough knowledge of many other branches of science and technology.

The problem of training engineering and technical specialists should be seriously treated in the developing countries as well, since experience proves that only that country may become actually independent which has a well-developed heavy industry and, particularly, a machine-building industry.

Training by the developing countries is effected mainly in two ways:

(*a*) By sending their citizens on a training mission into other countries with well-developed industries and wide experience in training specialists;

(*b*) By organizing the training of engineering and technical specialists in their own country.

Training missions to other countries is a necessity particularly during the first stage of independent development.

Domestic training of specialists will be successful if there is participation and assistance by some other countries.

The Soviet Union has wide experience in organizing and developing an educational system for training specialists. The well-known successes of the Soviet Union in science and technology and in space ventures were possible only due to the availability of a large number of its own national specialists and scientists. This experience will surely be useful to other countries which take the path of independent development.

In tsarist Russia (before 1917), three-quarters of the population were illiterate. There were only a few high and secondary special schools. This huge country had only 105 high schools including sixteen technical schools with 22,400 students.

The high schools were located mostly in Petersburg (Leningrad) and Moscow. The schools were attended only by representatives of the rich strata of society since the educational fee was too high. There were several groups of workers and peasants who had the luck to be enlisted into the schools. The representatives of other nations were not allowed to study at all.

The people's power has changed the tsarist educational system for the better. Now all forms of education are free. All the citizens of the Soviet Union have the right to an education irrespective of race, nationality, sex, religion, property and social status.

The schools may be attended also by foreigners living on the territory of the Soviet Union (in accordance with the "Convention on the Struggle against Discrimination in Education" adopted by the General Conference of UNESCO).

In the Soviet Union there is a united state system of education. This system ensures co-ordination and continuity of training at all stages of study.

The first stage is obligatory eight-year schools (of general education); the second stage is secondary education[1] (general secondary education: ten-year school; special secondary education: technical school); the third stage is higher education.

In addition, the educational system in the Soviet Union includes professional-technical training of workers (on the basis of obligatory eight-year education).

[1] It is planned to introduce obligatory secondary (ten-year) education by 1970.

Higher schools (universities and institutes) may be attended by persons who have secondary school certificates and who have passed the entrance tests. The entrance tests may be taken by any person (for the day departments there exists a thirty-five-year age limit while for the evening and correspondence departments there are no limitations at all).

When entering the engineering and technical faculties, the following tests should be passed: mathematics (oral and written tests) and physics (oral test), which are the main subjects, and chemistry (oral test) and Russian language and literature (written test) which are auxiliary subjects.

Those who enter higher schools in the Soviet socialist republics where education is carried out in the national language should pass a written test in the national language and literature instead of the Russian language and literature.

Students in the higher schools may include all the studies and use of laboratory equipment, textbooks and training appliances and sports equipment free. Medical service for the students is also free. When necessary, a hostel is provided for a small fee. Food is served in a refectory (located both in school and hostel) at prices considerably lower than in restaurants.

The majority of students get state scholarships (fixed money allowances to undergraduates).[2]

The number of higher schools and students in the Soviet Union is continuously growing.

In the 1963/64 academic year there were 742 higher schools in the Soviet Union with 3,261,000 students[3] including 43 per cent of women. The technical faculties of the higher schools (with the exception of agricultural engineers and technicians) were attended by 1,425,400 students. Special secondary schools were attended by 1,589,100 students. Twenty-nine per cent of the students in technical high schools were women.

In 1963, there were 331,700 post-graduates including 129,000 engineers.

In 1965, there were 403,900 higher school post-graduates.

In the 1965/66 academic year in the Soviet Union there were 756 higher schools with 3,861,000 students.

In 1966, the day departments of the higher schools only were to be entered by 404,900 students. The total number of students was to reach 868,000.

In the course of 1966–70, there will be trained about seven million specialists (post-graduates of the higher and secondary schools) which is 65 per cent more than during 1961–1965. By 1980, the number of students in the Soviet higher schools will reach eight million.

The number of specialists to be trained in the various branches of industry is determined by the general state plans on development of the economy. Therefore, all the postgraduates in the Soviet countries get jobs according to their specialities.

[2] Persons sent to an institute by an enterprise get the scholarship from the enterprise. This scholarship is 15 per cent larger than a general one. After graduation, these students go back to their enterprise.

[3] Including: 1,383,000 in day departments; 439,000 in evening departments and 1,439,000 in correspondence departments.

Higher schools are located throughout the huge area of the Soviet Union. Each Soviet socialist republic has its own higher schools. More than 80 per cent of the students are studying where the lectures are in their mother tongue.

During the first stages of development of the Soviet higher schools, considerable difficulties were encountered owing to the young people lacking secondary school certificates. Of great importance during this period were working faculties organized by the Soviet Government to reduce the terms of training of the workers and peasants for entering high schools. In the course of further development of a general secondary educational system and in the course of setting up the conditions for getting the secondary education by anyone who wishes, the need for the working faculties was eliminated.

General conceptions for training engineers and mechanics on metal cutting in the Soviet Union

The main problem faced by the Soviet's higher schools is training highly educated, active members of society, capable of independent and efficient labour in a selected branch of industry. The education of specialists is based on a combination of theoretical and practical training.

The mechanical engineer should be capable of designing, manufacturing and servicing machines. After graduation from an institute he should have a good knowledge of the fundamentals of scientific and technical achievements. He should be capable of using modern techniques and be ready for designing techniques of the future. Being a specialist in production means the mechanical engineer should be a good economist as well.

Engineering and technical specialists are trained both by the polytechnical institutes (technical universities) and by the higher schools of the branches of industry.

By way of exception, technical specialists are trained by some universities which commonly train specialists in humanitarian, physical, mathematical, chemical and other natural sciences. This is the case in some universities of the republics where there is a limited requirement for the engineers of some specific branch of industry. Mechanical engineers trained in metal cutting are turned out by eighty-five higher schools of the Soviet Union.

Training of highly educated specialists is effected both with work being discontinued (the so-called stationary or day high schools and their departments) and without discontinuing work (evening and correspondence high schools and their departments, technical high schools in the producing plants).

Studying with discontinuation of work

According to this system, the term of training the mechanical engineer equals four years ten months.

With due account for high rates of technical progress, high degree of automation of modern production, ever-growing requirements for the quality of the products, for the reliability and long life of the machines used in production of new materials, wide implementation of electronics, optics and computers, the mechanical engi-

neer should have a profound knowledge of a given branch of technology.

This means that he should be well trained in physics, mathematics and general techniques, should know the scientific and technical foundations of a given branch of industry, and be a specialist in some narrow branch. Good knowledge of physics, mathematics, and general techniques will enable the young specialist to settle independently most of the problems which will be encountered in his work, enabling him to improve the machines and to carry out scientific research. Specialization in some narrow branch of industry will enable the young specialist to work fruitfully in the economy immediately after graduation. Additionally, the mechanical engineer should be a good technologist and a good designer which will enable him to solve successfully specific production problems.

Let us consider in more detail the curriculum[4] for training the mechanical engineer on metal cutting (speciality: machine-building technology, metal-cutting machines, and metal-cutting tools).

The curriculum is divided into five years, each year divided into two terms. The duration of terms is: first term—18 weeks, second term—17 weeks, third term—18 weeks, fourth term—17 weeks, fifth term—18 weeks, sixth term—17 weeks, seventh term—18 weeks, eighth term—10 weeks, ninth term—10 weeks, tenth term—15 weeks.

About a third of the total time (4,328 hours) allotted in the curriculum for all types of education (including educational and productional practical work) is allocated for general scientific subjects which make up the theoretical fundamentals of the engineer. These subjects include social sciences (350 hours), higher mathematics (456 hours), physics (278 hours), chemistry (140 hours), and foreign language (210 hours). Higher mathematics is studied during the first, second, third and fourth terms; physics during the second, third and fourth terms; chemistry during the first and second terms; foreign languages during the first, second, third and fourth terms (English, French or German).

Physics as a natural science has become an active force in technical progress. Study of nature, knowledge of the natural laws, good knowledge of the basic sections of physics such as mechanics, electricity, optics, acoustics, thermodynamics, molecular physics and atomic physics—all this is of great value for the future theoretical and practical activity of the engineer.

The processes and laws of nature are recorded in the form of mathematical expressions. Therefore, the engineer should have a good command of mathematics, otherwise he will be unable to develop new machines and to elaborate new technological processes. The engineer should be knowledgeable in such branches of mathematics as differential equations, theory of probability, mathematic statistics, linear programming, theory of information, theory of series and the like.

About 1,500 hours are allotted for the study of general engineering subjects including: machine-building drawing—159 hours during the first, second, third, fourth and fifth terms; descriptive geometry—72 hours during the first term; theoretical mechanics—190 hours during the second, third and fourth terms; technology of metals and of other structural materials—142 hours during the third, fourth and fifth terms; structure of materials—88 hours during the fifth and sixth terms; resistance of materials—174 hours during the third and fourth terms; theory of gears and machines—87 hours during the fourth and fifth terms; machine components and handling and transportation facilities—142 hours during the fifth and sixth terms, fundamentals of interchangeability and technical measurements—72 hours during the fourth term; general electrotechnique—141 hours during the fifth and sixth terms; hydraulics—87 hours during the fifth and sixth terms; thermodynamics and heat transfer—51 hours during the sixth term; fundamentals of safety measures and fire prevention regulations—55 hours during the ninth and tenth terms; fundamentals of artistic design—36 hours during the seventh term; and computers in engineering and economical calculations—40 hours during the eighth term.

Since the metal-cutting mechanical engineer should be not only a technologist but also a designer of machines and tools used for metal cutting, the special subjects (with the total time of 900 hours) include theory of metal cutting—68 hours during the sixth term; metal-cutting machines—193 hours during the sixth and seventh terms; design and production of metal-cutting tools—112 hours during the seventh and eighth terms; machine-building technology—218 hours during the seventh, eighth, ninth, and tenth terms; machine electrical equipment—36 hours during the seventh term; fundamentals of machine appliance design—50 hours during the eighth term; fundamentals of machine-building plant design—50 hours during the ninth term; fundamentals of automation and productional process automatics—95 hours during the eighth, ninth, and tenth terms; and industrial electronics—51 hours during the sixth term.

The programmes for special subjects and the respective educational tasks for the students include calculations of the machines, their elements and units for strength, static rigidity, resistance to vibration, resistance to wear, long life, and the economical calculations as well.

In addition to the specified subjects, the curriculum provides allocation of 110 hours for study of obligatory subjects as determined by the council of the institute. These hours are allotted for study of additional sections of some subjects specified in the curriculum (e.g., for study of some chapters of higher mathematics, physics) and for study of some new special subjects relating to the branch of machinery selected by the metal-cutting mechanical engineer.

In the Moscow Machine-Tool Construction Institute which turns out the specialists for the machine-tool construction industry, mechanical engineers are trained in four more "narrow" specialities: metal-cutting machines, tool production, machine-building technology and electrophysical and electrochemical methods of material

[4] All curricula are approved by the Ministry of High and Secondary Special Education of the Soviet Union and are obligatory for all the schools training specialists of the same rating.

dimensional machining. About 420 hours are allotted in each speciality for studying special subjects.

These subjects are:

On the faculty of metal-cutting machines: machine-building technology – 70 hours during the eighth term (complete with the course project); design and construction of metal-cutting machines – 70 hours with the course project during the ninth term; fundametals of designing automatic machines, shops, and plants – 11 hours; hydro- and pneumoautomatics and equipment – 84 hours; machine electrical equipment – 84 hours.

On the faculty of tool production: tool-production machines – 36 hours; measuring tools and gauges – 40 hours; technology of tool production and design of appliances – 90 hours with the course project to be made during the eighth term; heat treatment of cutting tools and equipment of heat treatment shops – 54 hours; design and construction of cutting tools – 80 hours; dies – 30 hours; design of tool production shops – 30 hours; electrical equipment of tool production plants – 40 hours.

On the faculty of machine-building technology: machine-building technology – 80 hours for special sections, with the course project to be made during the ninth term; metal-cutting machines – 112 hours for special sections, with the course project to be made during the eighth term; technology of production of cast, forged and stamped parts – 60 hours; fundamentals of machine building shop design – 60 hours; fundamentals of appliance design – 54 hours; machine electrical equipment – 54 hours.

The mechanical engineer who controls complicated technological processes in the machine-building industry should have a good economics education. He should be capable of comparing the technical and economic parameters of several versions of a machine and independently selecting the optimal version of the machine, process, shop plan, and the like. To this end, such subjects are studied as industrial economy – 54 hours during the seventh term; organization and planning of enterprises – 105 hours during the eighth, ninth and tenth terms. Economics are considered also when studying some special subjects.

For the benefit of the physical development of the students, the curriculum provides 140 hours (during the first, second, third and fourth terms) for gymnastics which is obligatory for all.

The study of subjects specified in the curriculum is carried out in lectures (2,285 hours), laboratory work (638 hours) and practical work (1,100 hours).

Laboratory studies are an important element of the educational process. They contribute to mastering the required material and are essentially the beginning of scientific research. Carrying out the obligatory minimum laboratory work, the student obtains good habits for independent performance of experiments.

The practical laboratory work will become effective provided that:

(*a*) The laboratories of the institute are equipped with modern instruments and apparatus;

(*b*) The practical laboratory work on each subject is in close connexion (wherever and whenever it is possible) with the tasks and problems that are faced by science and production;

(*c*) The student (who has been preliminarily instructed) is entrusted with performance of an experiment, with processing the results, and with making conclusions.

All the laboratories of the higher school should be educational centres and scientific centres as well.

The higher school as well as any other school cannot function without textbooks and training appliances. The textbooks and training appliances which are needed in each subject should be as brief as possible and should comply with the respective approved programmes. The contents of the textbook are based on the latest achievements of the science and technique and therefore it is important to revise and republish textbooks. During revision of the textbooks, some of the material should be omitted, some of the material should be revised, and some of the material should be new.

In 1965 in the Soviet Union there were published 768 textbooks and training appliances for the higher schools.

The textbooks and training appliances, though being very important for training highly educated specialists, cannot often give answers to numerous questions arising during study of new material, during various home tasks, laboratory work, course (year) projects and projects presented for diploma. Hence each higher school has a library fully equipped with the required sources of information: reference books, encyclopedias, monographs and periodicals on all the subjects specified in the curriculum. The value of the library to the future engineer lies in the fact that in the course of his work there he acquires habits for self-controlled searches for scientific information.

Physical education and sport are considered as a continuous educational process consisting of a set of exercises and games and intended to add to the health of the students, to ensure their good physical development, education, sport improvement and to prepare the students for highly efficient labour and for defence of their motherland. The most widespread are such sports as gymnastics, basketball, volleyball, football, heavy and light athletics, rowing, skiing, skating, boxing and swimming. A large number of students has a passion for tourist and mountain trips.

The maximum load of the students by all types of studies including optional studies is thirty-six hours a week during the first through fourth years of education and thirty hours a week during the fifth year.

Much attention in training mechanical engineers is paid to acquiring the practical habits for work and studying up-to-date methods directly in the plant.

With this purpose in view, seventy hours are allotted during the first year of education for work in the studying shops of the institute and one month is allotted for practical (technological) work by the students in the best plants of the country. The studying shops of the institute have five sections (shops): casting shop, forging shop, welding shop, locksmith shop and mechanical (machine-building) shop.

In each shop, the student independently (under the supervision of his teacher and foreman) works at the bench station and performs all the necessary operations on production of some part, acquiring practical habits in manual and machine treatment of metals and non-metallic materials, basic technological methods of part production; becomes acquainted with the construction and operation of the equipment, cutting and measuring tools and appliances; becomes familiar with safety precautions and the arrangement of the work station.

Production (technological) work is carried out within twelve weeks, during the eighth term. During this practical work, the students acquire experience in solving practical problems in the machine-building plant. They should master the products manufactured by the plant, requirements for the products and basic technological processes. Special attention should be paid to studying the most economical and efficient technological processes in parts production (beginning with production of blanks and finishing with machine assembly and finishing operations), to the problems of mechanization and automation of the productional processes, organization of production, and safety precautions.

The practical work is carried out under the supervision of the professor and plant engineer.

The final production-practical work (designing-technological work) is carried out during the tenth term. During this fifteen weeks' practical work the student accumulates the material for the project presented for his diploma and therefore it is often termed pre-diploma practical work. This work also is carried out in the best machine-building plants, preference being granted to the plants in which the student is going to work after graduation (distribution of the students to the plants is effected one year before graduation from the institute).

To ensure that the future mechanical engineer will have the 'know-how' for designing and computation, the student in the institute undertakes two-course (year) tasks devoted to the fundamentals of automatics and automation of productional processes and to organization and planning of the enterprises and six-course (year) projects devoted to the theory of gears and machines, machine components, transportation and handling facilities, metal-cutting machines, metal-cutting tools, and machine-building technology.

For better appreciation of the material, homework is planned in some of the subjects including mathematics, theoretical mechanics, resistance to materials and theory of metal cutting.

There are exams and tests after each term. Grading is by the four-mark system: excellent (5), good (4), satisfactory (3) and unsatisfactory (2).

The final stage of training is performance and defence of the project (design) presented for diploma. The students are allowed to work on the diploma project provided that they have passed the whole of the training course in the institute. The time allotted for preparation of the diploma project is sixteen weeks.

The topic of the diploma project is selected by the student before the pre-diploma practical work, based on specific problems faced by the industry or on future problems.

By way of example, let us mention some of the topics of diploma projects: 'Technological process for manufacturing engine cylinder block for specified truck", "Technological process for manufacturing changeover gearbox for boring machine 2A450", "Gear grinding machine for wheels of up to 500 mm in diameter", "Drilling machine with timed control system", "Tools for automated production of turboaugers", "Tools for ball-bearing automatic production line".

One of the elements of the diploma project should be worked out by the student quite thoroughly with reference to experimental research.

The diploma project, consisting of ten to twelve sheets of drawings and 100–120 pages of notes is defended at an open meeting of the State Examination Committee whose staff is approved by the Ministry of High and Secondary Special Education.

After successful defence of the diploma project, the young specialist who has graduated from the institute with discontinuation of work receives a temporary certificate and a badge. The diploma is handed over after the expiration of one year during which he should prove that he is a good engineer. The engineer with 75 per cent "excellent" marks and 25 per cent "good" marks and who has defended the diploma with the "excellent" mark receives an excellent-student diploma.

The five-year training of the metal-cutting mechanical engineer consists of 251 weeks which are allotted as follows: 143 weeks, theoretical training with discontinuation of work; four weeks, studying practical work; twenty-seven weeks, production work; sixteen weeks, preparation of the diploma project; twenty-nine weeks, exams, and thirty-two weeks, vacations.

Recently, technical training means such as cinema films, computer (programmed) training, tape recorders, radio sets, television sets and the like have found extensive application.

Production and application of training films devoted to some subjects makes it possible to explain graphically difficult material.

Most of the institutes are equipped with cinematic and photographic laboratories. This work is also participated in by the cinema studios of our country. Control over the production of the cinema training films is exercised by the Ministry of High and Secondary Special Education. The circulation of the training films is directed by the Central Cinema Laboratory of the Ministry.

Short scientific and technical films are also produced for student use by the cinema studios.

Programmed training, which involves use of training and testing machines, makes it possible to increase appreciation of the material owing to participation also by the teacher and the possibility of simultaneous active participation of all the students in the study process (individual training). The programmed training makes it impossible for the student to neglect studies occasionally and adds to his self-control.

During programmed training, all material to be studied (from a special textbook or training appliance) is divided

into sections arranged in logical sequence. Only after mastering the previous section may the student go to the next one. Some material is introduced into the machines which enables the student to appreciate more what he has learned already. In this event, the machine does not act as a teacher. The machine does not teach the students but fulfils the programme prepared and introduced into it by the teacher.

Recorders find extensive application in learning foreign languages.

In our century of rapid development of science and technology, when science becomes an active productional force, the higher school will be unable to train a good specialist if the teaching staff does not carry out scientific research. Hence, all the chairs as a rule carry out scientific research which contributes to the increase of the level of the educational and training work with the students and promotes the raising of the scientific and pedagogical rating of the teaching staff.

This work is commonly and actively participated in by the students who take part in the theoretical and production work of the students' scientific circles headed by the professors and teachers of the institute. In these scientific circles, the students acquire the habits of scientific research.

Students also work in special students' designing and technological offices, thus giving practical assistance to production agencies. Some of the work carried out by the students in these offices may be considered as course (year) projects.

It is not enough for the student to be a good specialist. He should be an educated, life-loving person interested in literature, music, art and theatre. Therefore, an extensive cultural and educational programme is being carried out in all higher schools. Along with going to literary parties, exhibitions, theatres and sports events, the students are active in artistic circles, photography, cinematography and drawing.

Very popular now is the "Club of Funny and Sharp-Minded Youth". At the meetings of this club, the students groups (courses, faculties, or the whole institutes) compete in various kinds of amateur art, in knowledge and sharp-mindedness on various problems. Competition between institutes is shown on television. Judges are prominent scientists, writers, actors and artists.

Training without discontinuing work

Training of specialists for all branches of the national economy without discontinuing work is the basic method for increasing the cultural and technical level of the people as this system makes it possible to study after the work day. More than half of all the students in the higher and secondary special schools of the Soviet Union study without discontinuing their work.

There are three types of training engineering and technical specialists in the Soviet Union without discontinuing work: evening education, correspondence education and productional education (high schools in the producing plants).

The evening and correspondence educational systems involve the whole institutes and evening and correspondence faculties (departments) available in nearly all stationary (day) institutes.

All the citizens who passed the entrance tests may be enlisted in the evening or correspondence department of the engineering high school, but preference will be given to the persons who work in the same specialty (or close to it) as that which will be acquired by them in the high school. To ensure better preparation for the entrance tests and to recollect material studied in secondary school, the preparatory courses are organized by the institutes and production enterprises for those who desire to study in the institute without discontinuing their work. The studies in these preparatory courses which function for ten months are carried out in spare time (after the work is over).

The persons enlisted into the institute and successfully studying there (in the evening or correspondence departments) receive certain benefits established by the Government. Thus, when carrying out practical laboratory work or taking exams and tests, students are given additional leave with preservation of average monthly pay. This additional leave equals twenty days for students in the evening departments and thirty days for the students in the correspondence departments (during the first and second years of study). The students of the third, fourth, and fifth years are given thirty days in the evening departments and forty days in the correspondence departments.

When preparing and defending the diploma project, additional leave with preservation of average monthly pay is extended to four months. One month before preparation of the diploma project, the student may be given an additional month's leave for practical production work and preparation of materials. During this leave, the student receives the state scholarship in compliance with the common procedure.

Additionally, during a ten-month period before preparation of the diploma project, the students of the evening and correspondence departments have one free day a week for preparation. On such days, the students get 50 per cent of their pay. Besides, the student may have one or two days a week (at the student's option) without pay.

All those who work and who are allowed to take the entrance exams have the right to additional leave for fifteen days (plus the time for travelling) without pay.

In the evening system, the terms of training of the mechanical engineer on metal cutting (i.e., machine-building technology, metal-cutting machines and tools) is equal to five years and nine months. The total number of hours allotted for obligatory studies with the teacher is 3,296. There are six years of study, each being divided into two terms (the duration of the first term, 20 weeks; duration of the second term, 20 weeks; third term, 22 weeks; fourth term, 10 weeks; fifth term, 20 weeks; sixth term, 24 weeks; seventh term, 17 weeks; eighth term, 23 weeks; ninth term, 18 weeks; tenth term, 22 weeks; eleventh term, 10 weeks; twelfth term, 15 weeks allotted for preparation and defence of the diploma project).

Thus, the number of weeks is 300, including 206 weeks for theoretical studies without discontinuation of work, four weeks for practical production (pre-diploma) work,

fifteen weeks for preparation of the diploma project, twenty-five weeks for exam session, and fifty weeks for vacation.

The number of subjects and their nomenclature are the same as in the school plan for the mechanical engineer to be trained with discontinuation of work but the number of hours allotted to each subject for obligatory studies with the teacher is less. This is explained first by the fact that the students of the evening courses commonly have certain experience in their speciality, and secondly by the fact that the time allotted for study is limited. As a rule, evening students study in the institute four days a week, four hours a day (when free from work).

The volume of each subject is determined by the curriculum. This curriculum is commonly identical for all kinds of training. Hence, in the system of evening education a lot of attention is paid to elaboration and publication of proper textbooks and training appliances which may facilitate mastering of the material by the student of the evening course.

In the correspondence system, the term of training the mechanical engineer in metal cutting is equal to five years and nine months.

According to the correspondence system, the student is supposed to master independently all the subjects mentioned in the curriculum. The nomenclature and number of subjects are identical to those specified in the curriculum for studying with discontinuation of work. There are compiled several test tasks on each subject which should be fulfilled by the student with the aid of the textbooks and training appliances. The test tasks are delivered by the student to the institute.

In accordance with the correspondence system, the whole studying process is divided into years but not into terms as is the case with the day and evening systems. Once a year the student should pass a test on each subject. To take exams, the student goes to the institute once a year. This exam and laboratory session takes from four to six weeks. During this session, the student also carries out practical laboratory work and listens to reviews and lectures.

The higher schools engaged in training the mechanical engineers in accordance with the correspondence system have an extensive network of training and consulting stations located in other towns and on the plants in which there are many students. These stations make a record of studies of the students (who take the correspondence courses) living nearby, organize review lectures for these students (delivered both by the local teachers and by the teaching staff of the basic high school) and give consultations and tests.

Since 1962, there have been two stages of correspondence training. The first stage involves general technical faculties for the first three years. The general technical preparation includes mechanical, energetical, technological, mountain-metallurgical and constructional sections, enabling those who wish it to get higher education without discontinuation of work by studying for the first three years in the nearest institute or training and consultation station.

The second stage involves studying in the senior courses in the higher schools which prepare specialists for the branches of economy close to the branch in which the student is working.

The schools carrying out correspondence preparation of the technical specialists commonly organize day studies[5] devoted to the most difficult topics of the subjects.

On the general technical faculty these studies are planned to be conducted within thirty-five weeks, twelve hours a week, the total not over 420 hours a year. Correspondence course students who regularly attend day studies may be permitted to omit the test tasks.

For the students of the correspondence courses who may not attend the day studies, such studies are conducted during the exam and laboratory session.

The total time allotted by the curriculum for three years of the general technical faculty is equal to 147 weeks including 116 weeks for studying the subjects, thirteen weeks for carrying out laboratory work and taking the exams, and eighteen weeks for vacations.

The total time allotted for the next three years is 147 weeks including ninety-one weeks for studying the main subjects, eighteen weeks for carrying out laboratory work and taking the exams, four weeks for carrying out practical production pre-diploma work, sixteen weeks for preparation of the diploma project, and eighteen weeks for vacations.

To give assistance to the students of the correspondence courses and to enable them to study successfully all the subjects mentioned in the curriculum, special training lessons are conducted by radio and television.

Similar to the evening system of training, the studies in the correspondence system end in defence of the diploma project in the presence of the State Examination Committee after which the young engineer is awarded a diploma and a badge. All the diplomas are identical irrespective of the training system.

The term of training the mechanical engineer on metal cutting in the plant-technical higher school system is equal to five years and ten months.

Plant-technical higher schools are essentially a new type developed in the Soviet Union since 1960. They are distinguished from all other higher schools by a distinctive organization of the training process which combines theoretical studies with practical work on the plant for the whole of the training term.

These schools are organized in the largest and most progressive enterprises and function either as self-contained higher schools or at first as the branches of the stationary higher schools. Such plant-technical schools exist in the Moscow automobile plant named after I. A. Likhatchev, in the Leningrad metalworking plant and in the Dneprodzerdginsk metallurgical plant, among others.

The students of the schools are the employees of the given plant and the workers of the other plants (belonging to the same branch of the economy) who have graduated from secondary school, passed the entrance tests (in competition), and worked for at least two years in the plant.

[5] These are not obligatory for the correspondence students.

The theoretical studies which are not obligatory for the students are conducted in succession (by weeks or by terms): studies with discontinuation of work (as in the day system) are followed by work in the plant (studies being conducted similar to the evening system). When the student studies with discontinuation of work, he gets a scholarship from the plant. This scholarship is 15 per cent more than the common state scholarship for students of stationary day higher schools. The term of study with discontinuation of work is included in the whole length of service of the worker. The scholarship is also paid to the worker-student during an additional six- to twelve-day leave annually.

Some portion of the material is mastered directly on the working stations. The stations of the workers are changed in the course of their studies so that production work will contribute to a better understanding of the problems discussed in school. Additionally, the worker-students get special production assignments.

For instance, the following working position changes adopted for the students involved in "Machine-Building Technology": during the first year, the worker-students are employed as machine operators; during the second year, as locksmiths; during the third year, as shop superintendents and assistants; during the fourth year, as technologists; during the fifth year, as designers and during the sixth year as master technologists.

Such an organization of the training process makes it possible to reduce (as compared to the stationary day schools) the time period allotted for lectures, laboratory work and design work by 40 to 60 per cent and to increase by the same amount the time period allotted for general theoretical subjects, performance of research and scientific work and self-controlled studies.

Widely employed as the teachers of the plant-technical school are the highly-rated specialists of the plant.

The curriculum for training the mechanical engineer in accordance with the system includes the same subjects as the curriculum for engineers trained with discontinuation of work. The whole period allotted for studies is equal to 303 weeks, including ninety-four weeks for production work with training in accordance with the evening or correspondence system and ninety-four weeks for theoretical studies conducted with discontinuation of work. The student who will be turned out as a technological engineer on machine building should deliver one year's work on organization and planning of the plant and four year's work (projects) on theory of gears and machines, on machine components and handling facilities, on metal-cutting machines, and on machine-building technology.

The training process ends in defence of the diploma project. For preparation of the diploma project, the students are given a four month leave with pay.

Similar to other higher schools, a research scientific project is carried on to promote further progress of the plant

Assistance given by the Soviet Union in preparation of technical specialists for developing countries

The Soviet Union gives economic and cultural aid to young countries, one of the most important aid components being preparation of national technical specialist

The assistance is given in two ways: (*a*) training specialists in the Soviet higher schools; (*b*) assistance organization of the schools directly in the developi countries.

The number of highly-rated foreign specialists traine in the Soviet Union is increasing every year.

The schools of the Soviet Union turn out for th developing countries mechanical engineers, heat-energ engineers, electrical engineers, radio engineers, meta lurgical engineers, building engineers, hydrotechnica engineers, economic engineers and others.

The foreigners are accepted into the schools irrespec tive of their nationality, race, sex and religion provide that they have a secondary school certificate.

Foreigners who do not know the Russian language ar enlisted first on the preparatory faculties for one year Besides the Russian language, the preparatory faculties deal with mathematics, physics, chemistry, drawing and some other subjects with due regard to the speciality of the foreign student. These subjects are studied in order to acquaint the foreign student with Russian language terminology and to bring the level of his knowledge close to the school entrance level.

All the students from the developing countries study in the higher schools free. They have the right to use laboratories, libraries and sports equipment. All the foreign students get a scholarship of ninety roubles a month (eighty roubles on the preparatory faculties), are given a place in the hostel and get free medical service.

For the foreign students who have come into the Soviet Union from tropical countries, the schools obtain when necessary warm clothes (coat, cap, warm shoes). If the foreign students spend their summer vacations in the Soviet Union, they may be assisted in getting passes to the sanatoria, resthouses, in organization of excursions, tourist trips and travel. After graduation, the foreign student is given a free ticket to the capital of the country from which he has arrived.

The training of foreigners as mechanical engineers on metal cutting (and all other specialities as well) is carried on together with the Soviet students; the only exception consists in study of the social subjects (which are not obligatory for the foreigners) and of the foreign language which may be substituted for the Russian language).

The foreign students are enlisted into the same groups as the Soviet students. They should attend all obligatory studies (lectures, seminars, practical laboratory work), carry out all kinds of training tasks in due time, and pass all the tests.

On a par with the Soviet students, the foreign students take part in scientific research and may be elected to the councils of student scientific societies, sports clubs and student hostels and participate in amateur performances.

The foreign student who has fulfilled all the requirements of the school plan and curriculum is allowed to defend the diploma project, often devoted to the technological and production problems emanating from the specific problems of the student's motherland. Such

diploma projects are commonly taken back to their country.

After successful defence of the diploma project the State Examination Committee confers on the foreign student the rating of a mechanical engineer in accordance with the obtained speciality and gives him a standard diploma filled in two languages (in Russian and in foreign language selected by the student). The diploma is supplemented by a list which specifies the subjects and the grades. The best students receive the excellent diploma. All the postgraduates also get the badges.

The higher school diploma of the Soviet Union is equivalent to the master of science degree in the United States.

Apart from many higher and secondary schools which may be attended by foreigners, there is the University of Friendship of Peoples, named after Patrice Lumumba. The basic task of the university is giving assistance to the countries of Asia, Africa and Latin America in training national specialists and enabling the youth of these countries (especially the representatives of poor layers of society) to get high education.

The University of Friendship of Peoples was set up by the Soviet Government on 5 February 1960 in Moscow.

The assistance rendered by the Soviet Union to the developing countries in setting up their own high schools includes designing, constructing and equipping the schools, by elaborating and delivering textbooks and training appliances and by sending Soviet professors and teachers to work in the high schools of the developing countries.

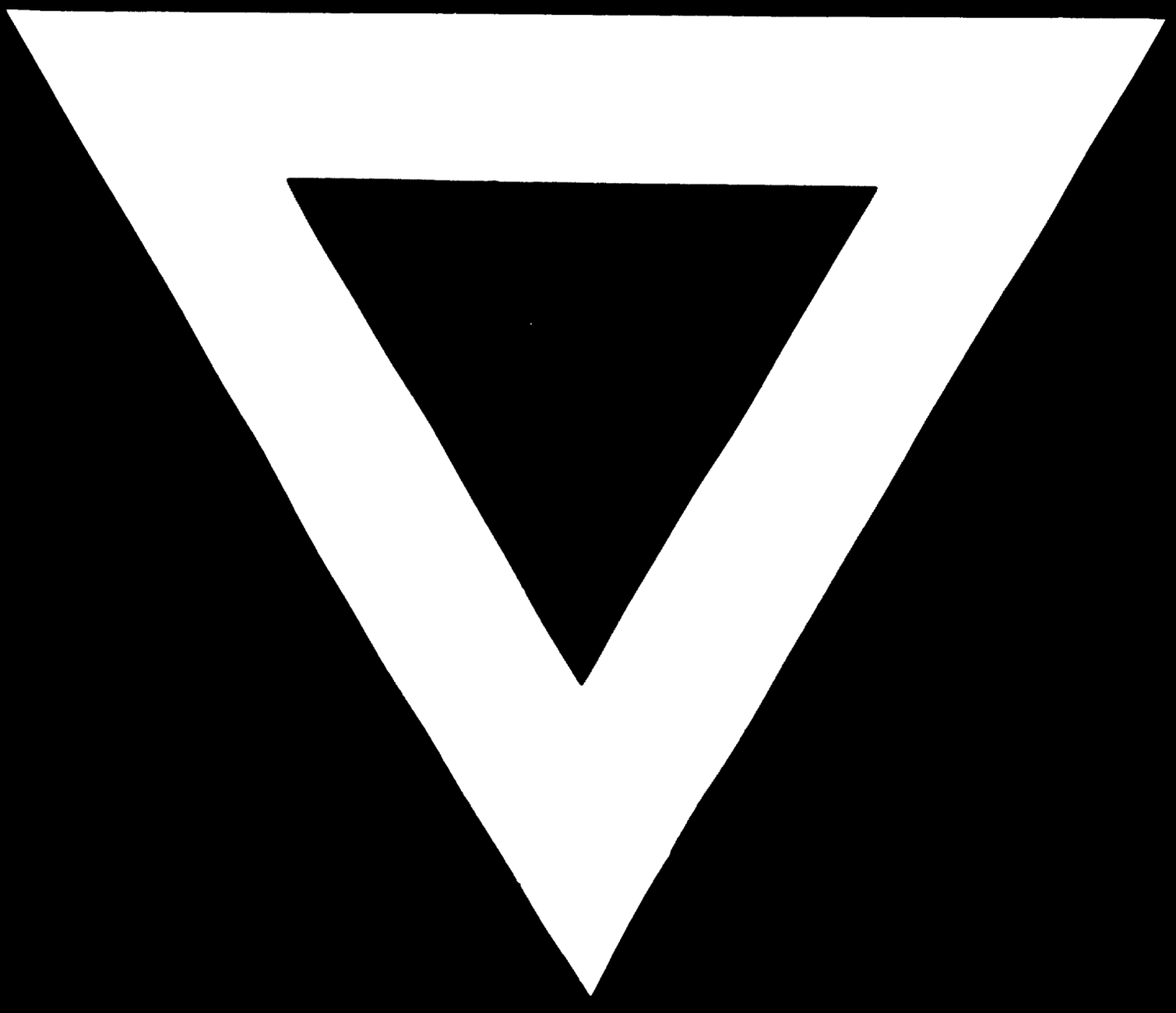
About ninety schools (institutes, colleges, technical and secondary schools) were or are being constructed in the developing countries with the aid of the Soviet Union. They include the Technological Institute in Bombay (India) rated for 2,000 students and postgraduates (1958); Technological Institute in Rangoon (Burma), for 1,100 students and 100 postgraduates (1960); Polytechnical Institute in Conakri (Guinea), for 1,100 students and 100 postgraduates (1962); High Technical School in Pnom-Penh (Cambodia), for 1,000 students; Oil and Gas Institute in Bumerdas (Algeria); and the Polytechnical Institute in Kabul (Afghanistan).

Specialization of the schools in developing countries is determined by the specific features of the historical, social-economic, economical and cultural development of each country. Considerable effect comes from the natural resources available in the country.

On the basis of the problems and perspectives of development of its country, the Polytechnical Institute in Guinea, for instance, turns out specialists in industrial and civilian construction, agriculture, prospecting and development of natural resources.

At the first stages of development of the national machine-building industry in the developing countries it is difficult to have specialized plants for production of the metal-cutting machines and tools. Therefore, the mechanical engineer on metal cutting should be rather universal, i.e., working on the machine-building plant he should be able to fulfil the functions of a designing engineer, technological engineer and mechanical engineer. In all these capacities he should be a good organizer capable of highly efficient and economical labour.

The progress of the higher educational system in the developing countries is also contributed to by the scientific and cultural relations between young institutes in these countries and higher schools of the Soviet Union. Mutual exchange of scientists delivering lectures, of publications, textbooks and training appliances, establishment of personal relations between the scientists and between the students' organizations all this promotes mutual enrichment of experiences gained in organization of the training processes and of scientific research.



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