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USSR: Computers

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SCIENCE & TECHNOLOGY

USSR: COMPUTERS

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PHYSICIST CHALLENGES PRETENTIONS OF COMPUTER OMNIPOTENCE

Moscow LITERATURNAYA GAZETA in Russian 17 Sep 86 p 10

[Article by I. Radkevich, Doctor of Physical-mathematical Sciences: "About the Computer--Without Singing Its Praises, under the "Conception" rubric]

[Text] Computerization of all spheres of human activity--a great number of newspaper articles are devoted to this grandiose technical revolution occurring right before our eyes. More than once in its own pages, "LG" has advocated the wide-spread potential of the computer.

And suddenly--an opinion which would be the exact opposite of the usual computer laudation. Who is its author, a moss-covered bureaucrat clinging to the past? Not at all! It is a serious physicist for whom work with computer science became necessary and ordinary long ago. It is because he superbly understands the inevitability of the computer revolution, that he, perhaps more clearly than others, sees the growing expenses of general computerization even now. The computer is an invaluable help to us, but only as an instrument. How it will be used depends on man, on us.

So that we do not have to throw our own blame on the inevitable technology, let's thing about it while it is not too late.

In recent years, a widely publicized thesis has appeared before us: "Programming--a second literacy." Its advocates believe that without this second literacy it will soon become impossible for any of us to work or live. It is as if we have decided to talk in the future not only with out computer but each other in machine language. This would be quite logical in the future when we would pursue the goal of completely replacing ourselves with intelligent machines and quietly exiting the stage of history like the dinosaurs which are extinct in our time. It is clear that this perspective appears quite outrageous to anyone.

Don't hurry dear reader just to attach a label to me of computer rebel, of such "Luddite of the XXI century." I know about the use computers yield to mankind today not by hearsay: many of the most important achievements in my professional field--physics of elementary particles--would be simply impossible without modern computers. But to the question do I need a computer in the laboratory I answer: it depends on what kind. Hiring a worker, they

are always interested in his possibilities, interests, and character. And they will not take just everyone. No one offers a job to a "general person"; they take a quite specific worker--a professional. Is that why leaders of industry and science, and workers in the sphere of management today complain of a shortage of "general computers" and "general programmers"?

What is programming? It is composing a regulated series of future actions for an electronic machine. Nothing more. By itself, such a procedure is meaningless if it is not known exactly how and why it is necessary to process (compute). If you know how to answer three of these cardinal questions--the rest, roughly speaking, are only a matter of technology.

Already, long-term world experience shows that teaching "pure programming" to people, not having extensive professional training in some kind of subject field, for their own liking of programming and computers themselves, educates programmers who do not know how to do anything in particular and who write programs which are used as a rule only by themselves. Joe Weizenbaum, author of the first programs in the history of science for "conversations" with the computer in natural human language (the "Eliza" program), very accurately described such a programmer. "His skill resembles the art of a copyist in a cloister; rude, but still first class calligraphy."

Since I am appearing in the pages of Literary Gazette, it would be appropriate to proceed with a literary example. Not just elegance of handwriting (made absolutely unnecessary with the invention of printing); or even smoothness of speech; or knowledge of a second, third, and so on, language would ever make anyone a good writer. Of course being tongue tied is not becoming to even the most talented man of letters, but without the main, professional quality--the gift of a thinker, story teller, or artist--the most refined technique of letters becomes no more than a beautiful instrument in the wrong hands. Hardly anyone will deny this now.

So I think the basic problem today is not the majority of workers have the absence of a "second literacy," but that more often the first is not up to standard--not the ability to read and write (that thank heavens we are being taught)--no, the professional training in the selected subject field, be it engineering or cooking, medicine or fire-fighting. And first of all, we should combat not computer illiteracy, but unprofessionalism in a subject.

Here is one of the striking facts which arises in such conditions of an unproductive alliance of applied mathematics with the subject specialists served by it (here--economists). The book, "Software for Decision Support Systems," published in 1985, makes use of the official list of figures which comes out in the State accounts, and which represents the total characteristics of economic activities of an enterprise. However, of all those 28 points enumerated there, no more than four characterize actual economic activity! The remaining 24, alas, have no direct relation to implementation by enterprises for their basic tasks. For illustration, I give six of the last "economic figures" in the list: the number of public unions and creative teams for perfecting the organization of labor, the number of members of such unions and teams, the amount of work fulfilled by them, the increase of skill

in various courses, organizations of progressive schools, and the presence of private creative plans.

It should be clear to any professional-scientist, even without special economic training: some of these figures can describe even obstacles to real industrial work, which Mayakovskiy beautifully described at one time in the poem "Prozasedavshiyesya".

When the cost of production, the productivity of labor, and other actual features of production are put on the same level with the number of participants in public and non-public unions and meetings, and all this is noted as a sign of quality by the use of the newest computers for such "calculations"--whether you want to or not, you will stop being surprised that the ASU systems on which have been spent considerable sums have not yet yielded a proper return. Let's leave the computer alone now and multiply by the usual logarithmic rule, the number points of useless (if not harmful) book-keeping by the number of enterprises in the country, and for a time require a worker to collect data on each point. An astronomical number of millions of man years wasted for nothing is obtained.

N. Winer, one of the founders of cybernetics, to the question why is the effectiveness of computer utilization so low--10 percent in all!--already answered in 1964, "because intelligence is needed in order to know what to give the computer." It is not without interest to note here that at the present time the effectiveness of computer application in the world has fallen even more to only several percent over all.

Today, being moved, we hear modern variations of Christmas stories about babies who "study cybernetics like arithmetic." And we forget that cybernetics without arithmetic is lifeless, that now it turns out not only scientists but some teachers know arithmetic poorly. The example given above, of enormous expenses on senseless book-keeping, shows that many of our workers who surely completed the institutions are actually at odds with arithmetic.

As a result of unprofessionalism, the old paper bureaucracy is now changing and in part already has changed to computer bureaucracy. And it is more dangerous in as much as between the new bureaucracy and the controller will stand the computer, behind which one can hide much more safely than behind any paper. If we did not yet succeed in stopping simple paper circulation, then how will we do it with a computer?! Information hidden from sight, of which it is impossible to take advantage without a computer; programs for distribution, containing random or specific errors introduced by careless workers--here are the kinds of problems that will have to be dealt with now.

The so-called business games, used for decision search, instruction, etc., have received wide distribution today. Models of events under study, developed by the specialists themselves, should be their basis. Academician N.N. Moiseyev, in the book "Mathematics Carries out an Experiment", wrote, "...In order to overcome an engineering problem it is necessary to clearly understand its content, that is, become an engineer oneself. The mathematician himself has to look for that 'pearl' which afterwards he will call a model.

Misunderstanding this principle often leads to a condition in which a perfectly-trained, capable, youth-mathematician, who finds himself in industry, does not find his own place."

So finding themselves in none of the subject fields, applied mathematicians and programmers became ardent propagandists for the unusual possibilities of abstract models and computers. The tragedy is that even students began to suggest that everything would be possible with the help of models--even inventions. Models can do everything! In the Saratov Economic Institute, models and "games" were developed for selecting the best method for treating patients. In that case we will be consistent: hastily we will replace all doctors with computers--and let schoolchildren and students develop and put into practice "the best methods for treatment." Will we last long after this?

It is not so easy to eradicate the unrealistic approach to the computer. The fact is that those who devote themselves to such theoretical simulations fall into rare comfortable conditions of complete irresponsibility; for without verification in practice, it is impossible to reject even one of their abstract models--even if it breaks a law of nature. And this allows those who are in no condition to give any kind of useful finished product to comfortably exist, and still get away with "electronic" semifinished products, substitutes, and simply promises to solve the posed problem in the future--when even more powerful computers will appear.

There is no simple exit from the most complicated situation. A tireless professional job is needed just to change to the rational use of all computer hardware. On an unprepared, methodological and material basis, an informatics course is being conducted in the schools. But the students themselves still have no professional training of any kind, and that is why, in the meantime, we can educate them only on abstract examples and models.

Academician A.A. Dorodnitsyn, explaining the reasons for the introduction of the term "informatics," wrote: cybernetics has grown "the malignant tumor of idle talk...people in the business began to be ashamed of attaching them to cybernetics...the necessity arose...to isolate themselves from the 'blown about' husks." Unfortunately, those unprofessional cybernetics, for which the reputation of "blown about" science was created, soon changed attire and now began to discredit informatics.

A complication of the rapid reorganization in this field has been connected, first of all, with having to change psychology radically. There is no other way out--it has to move from greatly comfortable conditions of almost complete irresponsibility for the end result, to risky work with real objectives, whose features, unlike the properties of models, are generally known far from completely. For many years the status of a super-science, capable of solving all problems, was imparted to cybernetics. In order to attract supporters, propaganda began to develop about discoveries made "on the tip of a pen."

As an example--the most uncommon if not the only one--the story is told of the discovery of the planet Neptune, based on the calculations of J. Adams and

U. Lever. However, this epochal success, if the truth be told, has been created not so much by calculations (the modern computer can make them very quickly, but it does not discover any new planets!), as by brilliant scientific hypotheses, which explain the variations of the orbit of Uranus observed by astronomers. Of course there could be other reasons for the disorder of the orbit, and then all the enormous labor of the computers would go to rack and ruin, and would be instantly forgotten. There-in lies the vitality of the half-truth: rarest successes are remembered indefinitely, but the inevitable in real life and science, numerous and "background" failures, are ignored. Although in expenses of labor, money, and time, this unavoidable "background" far exceeds the significant but always rare successes.

True science does not rely on special advertisement for drawing supporters--its best features are actual results. Indeed some discoveries are made with the help of a computer. What is more, in the physics of elementary particles, it is said that it is not possible to conduct even one serious experiment today without a powerful computer. However, it would occur to none of the researchers to say that the computer made the discovery for him, just as no novelist acknowledges as his co-author a typewriter or reference card index.

The computer, and mathematics itself, is an instrument in the hands of the researcher which helps man find truth (but does not make it for him). Gekslī once well said about this: "mathematics is like a mill stone, it grinds what is put under it, so having put in goosefoot, you do not get wheat flour, so having covered entire pages with formulas you do not get truth from false premises."

So, is it not time to honestly deliver the preliminary results, to call a spade a spade, to point out at least one discovery made by a nonprofessional with the help of a computer, even a most modern super-computer? At the same time it is necessary to at least roughly estimate the total expenses of all resources on the futile "computer games" conducted under the premise of searching for new solutions. Estimates show that the well known ASU and even NOT are now often unprofitable. You see, both systems have been around for many years already and should have emerged from the period of formation long ago.

The garish term "computer revolution" marks the culmination of the celebration of the computer. But its achievements have been rather small. Even in the USA where up to 7 percent of gross national revenue is spent of the creation of computers and programs for them, this in no way affected the continual reduction of the growth rate of labor productivity. What is more, the "computer boom" in the business and true science world of the West ended long ago. In the USA, only big business associated with the output of automatic game machines encourages advertisement.

In such a complex and neglected situation it is hardly possible to offer a collection of measures for solving problems in a rush. A multi-dimensional influence is necessary, a working dynamic system which would respond to changing influences from without. However, it is perfectly clear that now thoughtless propaganda about the omnipotence of the computer should be stopped, and attract professionals-specialists having real experience with

using computer science for solving quite specific problems to teaching applied informatics in the Vuses, in the professional trade improvement courses, and the like.

It is impossible to pass over in silence the fact that the lower effectiveness of computer use today is also explained by extremely poor business organization in many fields; computer science is again called on to handle these areas.

Here, let's say, are the automated design systems (SARP), "co-author of the designer," as the newspapers write about them. Let's say we are required to design a very simple object, for instance a primitive garbage shovel. A computer with the proper program develops the design in less than a second and several seconds pass for making the sketch with the help of an automatic plotter. The design of the shovel is ready. Is it ready? The system for approving documentation which exists today is such that just to approve the technical specifications on such a domestic shovel it will be necessary to collect 33 signatures (LG has written about this). If it is assumed that one day is enough for each signature, the length of creation time for our project grows a million times. Seconds for work and months for the bureaucratic red tape.

It is useful to remember that right before the war, a well-known gunsmith of ours, V.G. Grabin, developed and put into use--without any computer--a method of high speed design with simultaneous development of the technological process. This allowed him to collectively design an object, produce a prototype, and authorize it for production all in 72 days. And not just anything was made, but a famous regimental gun which was used throughout the entire war. Where can we really keep up with these speeds, if, as was written not long ago in Pravda, the time allowed for creative labor of the designer has declined in the last 30 years from 80 percent to 10-20 percent. And there is no point talking about professionalism when 9/10ths of the time goes to compiling papers that have no direct relation to the basic work.

The collapse of professionalism which affects all spheres of man's activities in one degree or another has many reasons, but probably, it is possible to call the sharp reduction in the seventies of the responsibility of the performer for the actual final result of labor, and the substitution of work by talking about it, foundational. This tendency found abundant ground, namely in informatics, which I would now put, on the part of the nonprofessionals in it, in second place after the administrative apparatus where the nonprofessionals are termed simply bureaucrats.

Extremely important to my mind is the process of training new science and engineering personnel. It is not the point to train one and all people to use a computer display or to teach them programming. Someone, no doubt, should seriously study this--the person who becomes occupied with creation of the computer itself and the development of its programs. However, the ordinary user--scientist, engineer, technician, or workers--soon after will probably associate with the computer, not in its language, but in his own--domestic or professional. Optimistic estimates suggest that this will begin

in the next several years. So why do we teach students today the universal languages of programming, which will most likely die out by the time the actual work of the present tenth-grade pupil will begin.

What it is necessary to teach--and teach at the most modern level--is true understanding of those natural phenomena or human society, which the future worker intends to research or utilize within the limits of his profession. It is necessary to develop a system for seriously improving the basic training of specialists, and having made such training active, then to impart the ability to use general laws for analysis of any new phenomena. The law of energy conservation, which says that energy is not obtained from nothing, converts packs of "innovative" compositions into unnecessary junk, which filter into print from time to time, but in essence, declare to the world only about yet another "perpetual motion machine." It is possible to perceive some analogy with this even in the unchecked advertisements for computers which supposedly make everything out of nothing. It is apparently advisable in all courses for improving skills to introduce short, recap-review courses on the basic laws of nature and society. But mimicking amateurs should not given them, the actual professional should.

Responsibility for the work--these are the key words which can determine the essence of reconstruction so necessary to all of us. At the XI party congress, V.I. Lenin said, "Instead of being responsible for your own work, submitting the decisions to Sovnarkom (Council of Peoples Commissars) and knowing that for this you will answer--they hide behind the commission. In the commissions there is no making head nor tail of it, no one investigates anything, some take responsibility; everything is confused and finally such a verdict is delivered in which all are responsible." Unfortunately, up to now the conscious responsibility of each person at his work place often is replaced by official fear of formal checkups "by committees" which are frequently less competent than the worker or collective being checked on. As a result, either everything is smooth only on paper, or unqualified analysis of the situation leads to acceptance of non-optimal and simply harmful decisions and gives rise to "reforms for appearance sake."

To think--it is necessary to think seriously and roll up one's sleeves and set to work. There is no time left for vacillating. As M.S. Gorbachev said, "the past has been exhausted."

PHOTO CAPTION

The idea of the "omnipotence" of the computer is not simply mistaken--it is becoming an obstacle to technical progress. So considers the physics specialist whose work is unthinkable without the most modern computers.

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CSO: 1863/37

THE VOLTMETER

Tallinn SOVIETSKAYA ESTONIYA in Russian 1 Oct 86 p 2

[Article by N. Bondar]

[Text] A group of engineers and scientists from the Tallinn Polytechnic Institute [TPI] and RET Production Association has been awarded the 1986 prize from the ESSR Council of Ministers, for creating and introducing synchronous converters into measuring equipment. Among them were Kh. Sillamaa, M. Min, T. Laud, T. Pungas, and others. Here is an assessment of the labor and those people by whose hands the first models of the innovations have been manufactured and tested.

This is the voltmeter we have known since our school days: an instrument which measures the voltage in an electric circuit. Designers, scientists, and specialists in repairing radio and other equipment widely use them.

But as many measurements as there are, there is also the problem of their accuracy. Different noises--hums--interfere with the voltmeters and sometimes cause severe errors in the instrument readings.

Hundreds and thousands of times noises can overshadow the signal which it is necessary to measure. And nevertheless, as is shown, it is possible to fully pick up this signal, however weak or variable the voltage. "Synchronous converters make it possible 'to catch' it in the sea of hums," tells Kh. Sillamaa, a candidate of technical sciences and assistant professor in the automation department of TPI,--"we even equip our voltmeters with such synchronous converters."

...Let's imagine swings. How do they swing them? With strong rhythmic resistance. At just the right moment a new force is introduced. The result depends on the total of them.

In synchronous converters there is the same principle swings (you see, synchronous means occurring precisely at the time). Only the methods and means of adjustment are electronic here, and the adjustment itself is carried out automatically. "Having swung" the caught signal, it is increased so that the noises no longer interfere with measuring it with the required accuracy.

They discovered the ability of the synchronous converter to increase only the desired signal in the thirties and began to use them in communication technology. Modern long-range communication would be impossible without them. But it is impossible to make use of such technological achievements for measuring technology immediately. A more accurate instrument is needed.

...Work on voltmeters with synchronous converters began in the republic about 20 years ago. At that time TPI and the present association RET concentrated their scientific and designing efforts on this problem. The matter seemed long-term although they did not hope for a quick ending to it. A group of enthusiasts, headed by Kh. Sillamaa, began to work on improving the existing voltmeter. The then students, Mart Min, Toomas Parve, and others, became interested assistants.

"In 1971," tells Kh. Sillamaa, "we had already created the first model of the so-called selective voltmeter. Amid the random noises it had to be able to isolate only that signal that it was necessary to measure. However, it was not enough just to create such an instrument, it still remained to "teach" it to work with a minimum number of errors."

And how did it work?

The problem was common to the institute and the enterprise. The circuit developed for the synchronous converter resolved everything correctly. A better version is continually being improved.

Incidentally, how do they find the low frequency signal in radio receivers and televisions? Namely with the synchronous method which permits achieving great accuracy. But if 30-50 percent errors are considered permissible in communications technology, then only within one percent is allowed in measuring instruments.

But let's get back to the enthusiasts. The students, who 200 years ago were members of the initial group, became engineers long ago. Mart Min and Toomas Parve did not give up working on voltmeters. Each of them introduced new ideas and problems into the matter and began to look for ways to solve them. Several solutions turned out to be inventions. It is natural that more than 10 inventor's certificates, or patents, showed up. The group has already been granted patents in the USA, England, France, and FRG...the talented engineers are doing their bit in the development of a world-wide measuring technology.

At the TPI they tried to find new areas of application for the synchronous converter. So instruments were developed for measuring very small variations of electrical properties in chemical solutions. They were intended for studying the kinetics of chemical processes at Tartuck University.

The results inspired the group and showed them that they were on the right track. In cooperation with the RET association, other ideas were embodied in the instruments. For example, the vector voltmeter.

It can simultaneously measure several properties of one complex signal, as if producing a "portrait" facing front and in profile. We are trying to use the vector voltmeter for technical control of the quality of those components furnished to RET. Besides that--in diagnostics of units being produced. The voltmeter "locates" a flaw immediately and a faulty component does not get into the finished product. The economic profit is obvious. The test run of this instrument is carried out at RET. Even our own microcomputer is involved in the latest test models of the vector voltmeter. With its help, the instrument can, for example, estimate what it does not succeed in measuring.

How much do vector voltmeters cost? The most exact standard in the world market--several times more than an automobile.

Work on the instruments continues and new forces join the ranks. Raul Land, a young engineer at TPI, for several months looked for the "mysterious" cause of defects which appeared in the voltmeters in the micro-spectrums. It was necessary to search at times almost empirically: relying not only on knowledge, but also on intuition. Finally, his efforts were rewarded--Land found where the mistake was.

"Eight hours of work a day", said Kh. Sillamaa, "would give us nothing. We worked as much as the matter required. Striving to do better and more, united everyone. One can judge the performance from the results."

They are indeed considerable.

PHOTO CAPTION

"Eight hours of work a day would give us nothing. We worked as much as the matter required," (Assistant professor Mart Min (on the right) and junior science researcher Ants Ronk at the instrument). Photo by K. Liyva.

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IMPROVING DATABASE ORGANIZATION AND MANAGEMENT OF SCIENTIFIC AND TECHNICAL PREPARATION OF SECTOR OUTPUT BASED ON UNIFIED SYSTEM OF NOTATION OF PRODUCTS AND DESIGN DOCUMENT NOTATION, REGULATED BY GOST 2.201-80

Moscow STANDARTY I KACHESTVO in Russian No 3, Mar 87 pp 50-55

[Article by Yu. A. Miroshnichenko]

[Text] An increase in the volumes of output and a sharp increase of labor productivity require improvement in organizational and technical measures, i.e., of the forms and methods of organization and of the functional principles of scientific and technical preparation of production (NTPP). All these measures are primarily based on application of the systems and continuity principles that make it possible to intensify in the best manner the processes implemented in scientific and technological preparation of production.

The main features of managing the systems and success of development of industrial output and of its elements is formulation and effective use of a database organization and management system for scientific and technological preparation of production (SIO NTPP), which makes it possible:

- to increase the completeness and currentness of supporting the technical decision-making process by using information about design (production) objects, methods of developing them and conditions of use;

- to create conditions for organization of permanent data files on production objects that ensure solution of a combination of problems in ASUP [plant management automation system], ASTPP [automation system for technological preparation of production] and other automated systems of a technological profile;

- to ensure information compatability of management systems that function in the overall structure of the NTPP.

The tasks of the database organization and management system, when observing the principle of continuity in the NTPP, essentially reduce to accumulation, storage and retrieval of the required technical and economic information about objects.

The specific features of the designation of the database organization and management system of the NTPP, the types of objects and data storage devices and the nature of the management tasks to be solved in the NTPP clearly determine in practice the need to use the sequential coding method in the system, based, as is known, on preliminary hierarchical classification of objects according to their production design features. The indicated circumstances determine the need for introduction and universal application of a unified system of product and design document notation at enterprises and in organizations of the sector, according to GOST [State Standard] 2.201-80, which most fully satisfies the conditions of the designation and functioning of the database organization and management system of the NTPP. Introduction of GOST 2.201-80 and of the YeSKD Classifier into the activity of scientific research, planning-design and industrial enterprises in our sector is being implemented in phases with regard to the sequentially implemented plans for improving the forms and methods of management of the NTPP.

The tasks to be solved by the sector at the current phase include conversion of machining production to part-group specialization. As is known, the basis of this form of organization of production is the principle of group technology, which assumes preliminary grouping of parts according to specific production design features. The production design classification of parts proposed by VNIINMASH [All-Union Scientific Research Institute for Standardization in Machine Building] is used as the means of optimal ordering of the numbers for these purposes. It is being implemented according to the geometric shapes of parts, which facilitates grouping of them when organizing the parts-group specialization of production.

Deviation from this constitutional principle of parts classification, toward which some specialists have called for recently, fighting against parts classification according to the feature of the functions performed by them, may lead to unrecoverable losses of the qualitative characteristics of the classification system and, as a result, to the impossibility of using it to solve a number of essentially important problems in technological preparation of production.

It is appropriate to recall in this regard that the classification of parts according to the functions to be performed was the main disadvantage with all the positive qualities which the parts classification and coding system, adopted in MNSChKh [not further identified] (NO.000.005), had. As a result, parts completely identical in geometric shape, but which perform different operational functions, had different code notations that did not permit grouping them according to unified geometric shapes and other production design features.

With regard to these circumstances, we cannot help but express our concern about the newly developed polemics on review of the design principles of classes of parts of the YeSKD Classifier. Let us assume that any attempt to change the parts classification system, adopted in the YeSKD Classifier, had a negative effect not only on the capabilities of using it when organizing parts-group specialization of production, but also in all similar management tasks to be implemented in the NTPP.

For example, the need to reduce the deadlines for technological preparation of production and to reduce the labor intensiveness of the tasks to be solved in this phase of the NTPP forced the enterprises of the sector to use a parts classification and coding system according to GOST 2.201-80 as a machine-oriented language for communicating with data files about production objects under conditions of functioning of ASUP, ASTPP and other automated systems of technological designation as well.

It is known, specifically, that the tasks of technological preparation of production (current-calendar planning, material and technical support, developmental preparation of production and so on) essentially began with solution of the problem of the so-called disassembly of products, in which the nomenclature composition of the product is determined by name and in which subsequent technical and economic planning of production and unincorporation are implemented on its basis. Disassembly of the product itself assumes grouping of its constituent parts--parts and assembly units (DSE)--according to specific production design features for solution of production management tasks. It becomes necessary in this regard to use for these purposes a production design product classification system, since the parts and assembly units can be grouped in the automated mode according to given production design features only on its basis. In turn, the use of the decimal system of coding these features in the devices for storing information about the production (design) objects--design documents--makes it possible to combine the design and technological preparation of production according to information content, thus eliminating the process of recoding the information.

The product classification and design-feature coding system, established by GOST 2.201-80, and its logical continuation--the parts production design classification and coding system--were used when solving the problems of technological preparation of production at one of the industrial enterprises of the sector, which made it possible to solve more than 30 problems within the ASUP and ASTPP for a number of basic products and to achieve a significant reduction of the deadlines and reduction of the labor intensiveness of operations that were earlier performed manually. It was specifically possible to do away with working out production planning charts and a number of documents, previously used in organization of production preparation and management, since the information required for these purposes is published directly from the plant computer center in the data for disassembly of products. Unfortunately, it is impossible to present data about the real technical and economic effect, achieved as a result of introducing GOST 2.201-80, since these calculations were not made, while the process of introducing the system is being continued by expanding the volume of production management tasks to be solved by using it.

The areas of application of the unified product notation and design document system according to GOST 2.201-80 in the overall structure of the NTPP also includes planning design preparation of production (PKPP). Conditions are created on its basis for retrieving document and factual data about design objects for the purpose of borrowing them in a new design and for raising the level of continuity of engineering models to be developed. The given task is now especially timely for our sector, since the planned modernization of existing

products and development of new promising products should be implemented with minimal time and labor expenditures.

The envisioned increase of the level of intradesign and interdesign standardization of developments sharply poses the problem of improving the database organization and management system of PKPP and the need to develop automated information retrieval systems (AIPS) in planning and design organizations of the sector, which implement automated accumulation, storage, restoration, retrieval and output of the information required for design in the appropriate format. The presence of an automated information retrieval system as a subsystem of the PKPP provides a signal database for all similar functional subsystems of the database organization and management system of the PKPP, permits one to simplify considerably the information relationships between them and thus to increase the effectiveness of the PKPP as a whole.

Since the main element of the database organization and management system of the PKPP is the information retrieval language (IPYa), which is a character system designed to express the semantic content of documents and of information queries in a format acceptable for algorithmic implementation of information retrieval, it has been proposed that a unified product and design document classification and coding system according to GOST 2.201-80 be used as the required information retrieval language for the database organization and management system of the PKPP.

The need to achieve the greatest technical and economic effectiveness by observing the principles of continuity in planning and design developments on the basis of using a notation system according to GOST 2.201-80 (in the quality indicated above) and of the YeSKD Classifier led our sector to the need to develop automated information retrieval systems of the corresponding designation. Preliminary investigations, conducted for this purpose, and individual applications developments made it possible to formulate the overall design principles of the automated information retrieval system, the structure of which and functioning to ensure the given conditions are determined by:

- an automated data bank (ABD);
- an automated program fund (AFP);
- an automated document fund (AFD);
- an interactive automated retrieval system (DASP);
- a database management system (SUBD).

The interactive automated retrieval system, as the basic subsystem of the automated information retrieval system, is the user monitor and it contains program modules and classification databases, providing:

- access from a remote video terminal (VT) to the object databases,
- applications program packages and documents in the interactive mode in natural language;

formulation of retrieval instructions for automated data retrieval;

receipt of requested data and transmission of them to other users and also entry of them into automated systems.

Interactive information retrieval is achieved in the "menu selection" mode, when the user receives a list of thematic sections on the video terminal screen before formulating the next request. He implements the request, indicating the code of the section of interest to him, after which the interactive automated retrieval system displays on the screen a list of the subject subsections contained in the section, indicated by the user. The lists (retrieval databases) form a hierarchical classification scheme of thematic sections of information of the automated information retrieval system. The name of the sections is compiled by the information retrieval language while the codes of the sections compile the coding system. The user "selects the menu" to some level of classification in the automated information retrieval mode, upon arriving to which the interactive automated retrieval system displays to the screen an object-characteristic table of retrieval instructions.

The automated data bank is an ordering of a set of records (basis), which contain factual information on different properties of objects:

- parameters (dimensions of parts, composition of materials, method of surface machining and so on);

- physical properties of objects (operating reliability, strength, quality of surface machining and so on);

- the encoded structures of objects (for example, specifications and lists of reference documents which are used to fix the relationships of input and subordination between constituent parts);

- retrieval forms of documents, compiled from the code notations of key objects to which the documents belong.

The distinguishing feature of databases is the capability of offline use of each information element during automated transmission, retrieval and processing.

As analysis showed, a memory capacity of 10^9 - 10^{11} bytes, which considerably exceeds the modern capabilities of a single magnetic data storage device, is required to record only the most important (reference) data about all the products to be developed in the average capacity of the design office. Therefore, formulation of a complete automated data base requires creation of a library of magnetic tapes and disks. Creation of an automated database by using a single fifth-generation computer is possible in the future.

The main part of the automated program fund is an algorithmized model of knowledge, i.e., a systems-oriented combination of logic and mathematical algorithms, computing methods and mathematical models. The automated program fund should also contain a set of logic algorithms for flexible formulation of input data for operation of individual data processing programs.

The automated document fund is a system designed for ordered VCR recording of document images, correction of them, online retrieval and display on video terminal screens. It is assumed that the use of VCR records of documents will permit a 10^2 - 10^4 -fold increase of the write density of text documents to magnetic storage devices, compared to traditional recording in binary code, and will also provide the maximum speed and accuracy of recording. The write density of drawing-graphics documents can be increased 10^3 - 10^5 -fold. The VCR images of documents (VID) will be used in the automated information retrieval system to support decision-making about borrowing of previously developed objects. The file of VCR images of documents is ordered according to the code notations of objects to which they belong, i.e., on the basis of the classification characteristics for the YeSKD Classifier.

And, finally, the database management system is an operator monitor of the automated information retrieval system, i.e., a combination of systems devices which can be used:

- to call the required input data, programs and VCR images of documents;
- to enter new data and programs into the automated database, automated program fund and automated document fund;
- to check and make changes in the records of data, programs and VCR images of documents;
- to protect databases, programs and VCR images of documents against unauthorized access.

Only these design and functional principles of an automated information retrieval system, in which the product notation system according to GOST 2.201-80 is used as the information retrieval language, we feel, permit one to talk about the technical and economic effectiveness of introduction of GOST 2.201-80 with respect to the conditions for completion of planning and design work. The fact is that the use of the notation system according to GOST 2.201-80 only for ordering the document information storage devices on the basis of the YeSKD Classifier results in enormous time and material labor expenditures without achieving the necessary technical and economic effect, if the newly ordered document classifier file is not itself inscribed in the corresponding automated information retrieval system, which makes it possible to obtain online the factual-document information required for planning and design developments.

A specialized automated information retrieval system has been created on the outline principles of one of the design organization of the sector. It is planned to disseminate the experience of developing the system in other planning design sectors of the sector as this work is completed.

It should be especially noted that the problem of conversion of design organizations to the new product notation system according to GOST 2.201-80 is frequently difficult in the psychological aspect. Without achieving a direct

saving due to introduction of GOST 2.201-80 according to the outlined principles at the current phase, the design offices and scientific research institutes are preparing, without the proper enthusiasm to realize the corresponding organizational and technical measures. Moreover, whereas conversion to the new system according to GOST 2.201-80 is essentially unrelated to changing the existing system of accounting, storage and access to design documentation for organizations that previously used the depersonalized notation system according to NMSchKh, the forthcoming introduction of GOST 2.201-80 is primarily being evaluated as the need for significant reorganization of the technical documentation services and for changing the tradition of access of the document classification for enterprises which utilized the subject notation system according to GOST 5294-60. It is understandable that overcoming this psychological barrier is a difficult matter.

And nevertheless, the design offices that develop the basic design documentation systems for the plant encoded the information for the entire list of serially manufactured products at one of the industrial enterprises of the sector in the case of introducing GOST 2.201-80 for solution of problems in the plant management automation system. This process was accompanied by introduction of new notations according to GOST 2.201-80 in specification of complete sets of design documents, without renotating the basic design documents.

Conversion to the new notation system is being implemented at some other scientific research institutes and design offices that are ensuring introduction of GOST 2.201-80 ahead of schedule from new developments directly for the entire complete design documentation system. The earlier developed documentation is being renotated as it is borrowed for new design developments.

The following have been worked out by the sector head organization for standardization, responsible for solution of the given problem, for preparation for universal introduction of GOST 2.201-80:

- a sector plan for primary organizational and technical measures to introduce the production design classification and coding system;

- a specific sector integrated program of types of jobs and organizational and technical measures for universal use of the product classification and coding production design system in the database organization and management system of the sector NTPP (OTsKP KTKI).

The plan of primary organizational and technical measures contains recommendations on solution of problems that ensure:

- completion of jobs to develop and publish sector classes of the YeSKD Classifier and to acquire typographic examples of classes of other sectors of industry and an illustrated parts identifier for the enterprises and organizations of the sector;

- development, confirmation and publication of sector procedural instructions on introduction and management of a unified unionwide product and design document notation system, regulated by GOST 2.201-80;

development and introduction of a production design machining parts classification and coding system for conversion of industrial enterprises of the sector to parts-group specialization of production;

popularization of the production design product classification and coding system, including development and publication of a training-procedural handbook and study of the design principles and use of the system for enterprises and organizations at the sector institute for improvement of skills and in other forms of improving the qualifications of managers and engineering and technical personnel.

The mentioned sector specific integrated program for the production design product classification and coding system, developed as an application to a sector order being prepared on introduction of GOST 2.201-80 and the YeSKD Classifier, is a developed plan of organizational and technical measures and of types of work subject to implementation to ensure universal use of the system in all management phases of the NTPP in the sector.

For example, development and introduction of sector standard technical and methodical documents of the following designation are planned:

- on the procedure and rules of borrowing previously developed design documentation in new designs;
- on material incentives for borrowing "finished" planning-design solutions;
- on rules for notation of "nongraphic" parts;
- on the procedure for conversion of an existing fund of depersonalized drawings of sector application to notations according to GOST 2.201-80;
- on the rules of recoding previously developed design documentation to notations according to GOST 2.201-80.

It is also planned to implement a significant work plan in volume content to ensure introduction of the production design parts classification and coding system for different methods of manufacture.

The developments implemented in the sector for future conversion to the parts and design document notation system according to GOST 2.201-80 and to a logical continuation of it--to a production design parts classification and coding system--permit one to predict the need to develop a corresponding plan of measures of the intersector level, development of which can be entrusted to GNITsVOK [not further identified] and VNIINMASH of USSR Gosstandart. The fact is that the unionwide organizational measures envisioned by decree No. 58 of Gosstandart, dated 11 April 1985, is, we feel, only of the nature of primary measures, i.e., of measures needed directly for introduction of GOST 2.201-80 and the YeSKD Classifier. Practice suggests that universal introduction of GOST 2.201-80, the YeSKD Classifier and the production design product classification and coding system in all areas of management of the NTPP will leave open the

number of rather complicated and unresolved problems of an intersector nature, with regard to which it is suggested that a corresponding future plan of developments be worked out that also take into account the results of introduction of GOST 2.201-80 and of the YeSKD Classifier ahead of schedule.

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EXPERIENCE OF CLASSIFICATION AND CODING OF DESIGN DOCUMENTS

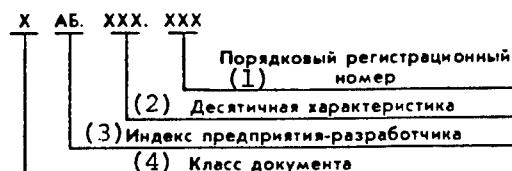
Moscow STANDARTY I KACHESTVO in Russian No 3, Mar 87, pp 55-57

[Article by B. M. Aksenov]

[Text] We would like to share our work experience with respect to design document classification and coding in regard to the discussion raised on the pages of STANDARTY I KACHESTVO, No 10, 1986 (pp 35-39) on the feasibility of introducing GOST 2.201-80 and the YeSKD Classifier.

Design documentation was encoded at our enterprise prior to 1982 according to the electrical engineering classifier, i.e., according to a depersonalized notation system. It should be noted that our enterprise is operating according to documentation, developed in the chief designer's department. This has its characteristic features, since a number of problems, related to development of introduction, production, operation and repair of manufactured products, is solved immediately with this approach.

The structure notation of the basic design document, used at our enterprise, is presented in the diagram.



Key:

- | | |
|--------------------------------|----------------------------------|
| 1. Ordinal registration number | 3. Index of developer enterprise |
| 2. Decimal characteristic | 4. Class of document |

The class of the document was enciphered in the following manner:

0--technical documents;

1, 2, 3, 4--products;

5, 6--assembly units;

8--parts;

7, 9--reserve.

Compared to the notation according to the YeSKD Classifier, this notation has the following advantages:

one can always determine what is being discussed--a document, assembly unit and so on--from the first number;

the decimal characteristic, consisting of only three numbers, is easily remembered not only by designers and technicians but also by production workers as well: foreman, supervisors and job distributors. The specialization billet production shops and sections, when machining is grouped according to types of parts or assembly units, helps the memorization;

separating the notation using the letter index of the developer enterprise is visually perceived better and more easily numbered.

Moreover, rigid tie-in of the name of the part or assembly unit to the classification characteristic exists in the electrical engineering classifier.

notation (coding) of design documents;

possibility of remembering them by all personnel of the enterprise;

computer processing of documentation when solving management tasks (in an ASU);

storage of documentation in an archive in cells according to the format for the first six characters of the notation in the order of increase of the ordinal numbers of documents;

standardization (consideration of applicability, compilation of classification and further standardization tables, borrowing and so on).

It should be noted that the capacity of the classifier was sufficient over 20 years of operation, since only two- or three-tenths of the characteristics were essentially used and the reserve was borrowed. The disadvantages of the classifier may include the inadequacy of the classification features (by designation only). This was especially manifested upon compilation of classification and standardization tables.

The use of computers at the enterprise made it possible to write all data to magnetic storage devices and to solve even specific problems of standardization, such as accounting for the applicability of parts and assembly units in the products of the enterprise and also of materials and makeup articles in the parts and in the assembly units and so on. To tie one or another drawing to the first product for which it was developed, there was the corresponding data in a column of 25 main headings, i.e., this brought it close to some extent to the information content inherent to the subject notation system.

If there was a need to fabricate parts and assembly units for repair purposes, the required drawing was found by name using the applicability card file.

There were also no difficulties in the use of the documentation of related enterprises, since it also had notation according to the electrical engineering classifier.

Accordingly, there was no objective need to introduce the YeSKD Classifier at the enterprise.

Specialists of the enterprise participated in a discussion of the design of the YeSKD Classifier, but they were unable to foresee the disadvantages which were determined during introduction of it.

As is known, electrical engineering enterprises were some of the first to begin introduction of the YeSKD Classifier. This was done under pressure of GOS [not further identified] and BOS [not further identified] and was caused by the need to certify products according to categories of quality (i.e., the enterprise was unable to certify products without notations of products according to the YeSKD Classifier).

Difficulties began with document coding, since the parts must be coded according to their geometric shape, while the name differed sharply from that used in the electrical engineering classifier. An end shield, known by this name to everyone, had to be called a flange (many other examples could be cited).

The number of characters of the code was increased sharply from 9 to 13 and the order of writing the notation was also changed.

Six rather than three characters of the decimal characteristic had to be memorized immediately--the code of the classification characteristic.

It should be emphasized that our enterprise operated according to the depersonalized notation system and it would seem that the conversion should be made with no problems. What can be said about enterprises operating according to the subject system of notations (GOST 5294-60)?

It was proposed during the transitional period:

that new products be denoted by the YeSKD Classifier;

that old documents should receive a double notation for two classifiers (the electrical engineering classifier was used in previously developed products and the YeSKD Classifier was used in new products);

the drawing in the archive had to be accounted for according to the new notation (according to the YeSKD Classifier).

This postulation of the problem possibly causes no complications in planning organizations where the main concern is with documents. This "double bookkeeping" results in confusion at an enterprise where the plant operates according to documentation. Imagine how one plans manufacture of a part with double notation?

It was especially difficult for the shop specialist to overcome the psychological barrier when operating by two systems. There was lack of coordination and there were many applications with a request for release from workers involved in production supervision.

The work of the archive became complicated--its capacity had to be increased.

The debugged ASU began to limp along on both legs, since it was necessary to create a new document file according to the YeSKD Classifier. Summation of parts and assembly units with double notation for two files had to be completed by hand.

And there was no end to this confusion: some products had to be manufactured for a specific time with notation according to the electrical engineering classifier, while the conversion of them to the new Classifier was not supported either with personnel or the capabilities of the enterprise.

Extensive funds were expended on all this work and the promised future saving is very problematical.

For example, let us turn to the specifications worked out during introduction of the YeSKD Classifier (TU 16-526.648-85) and let us determine which codes should now be assigned to an electric motor with height of the rotational axis of 355 mm:

IYeYuV 526822.004-01 is the notation of the main design document assigned by GOS;

3334720201 08 is the OKP [unionwide product classifier], assigned to BOS;

IYeYuV 525800.002 TU is the notation of the specifications assigned by the developer enterprise to the design documentation;

TU 16-526.648-85 is the notation of the specifications assigned by GOS.

And all this information is related to a motor of type AO4-355Kh-4U2, 6,000 V (the notation is assigned by the enterprise).

How much time and paper must the developer waste on requests and answers to obtain all these notations and codes. Are we not being too extravagant?

We feel that a reasonable way out of the established situation can be found.

For example, assign the notation of the OKP code to the main design document. Thus, one can immediately do away with several tens of classes of the YeSKD Classifier. The authors of the article proposed lists.¹ This question was raised at a seminar in December 1985, held by USSR Gosstandart jointly with the Sverdlovsk House of Engineering on Problems of introducing the YeSKD Classifier. A. I. Karpenko, a representative of GNITsVOK, then convinced the audience that this could not be done because of the different goals which these documents have. This means that the standardization had to be carried out.

When developing the new YeSKD Classifier with reduced capacity, it was necessary to take as a basis the existing depersonalized system (for example, the electrical engineering system) and to expand its capacity by using the reserves and also to permit a product code (index), if there was a need for those who are unable to cope with this idea.

The code of the enterprise is left as two-character, i.e., to agree with the authors of the article. At the same time, a single notation without a document is dead, while there is column 9 of the main inscription on the design document, into which one can write the code of the enterprise. Thus, one can reduce the number of characters in the notation.

We feel that the notation of class should be entered in GOST 2.201-80 in front of the developer organization code and thus reduce the code of the characteristic to four characters (they are more easily remembered).

Any work on standardization should be substantiated economically and the enterprise should be interested in introduction of it. One of the sources of an economy, according to the words of the authors of the YeSKD Classifier, is the capability of borrowing developments and technology. The bird is still free. The last bird must be lost to catch the goose, especially with the current shortage of engineering personnel.

The YeSKD Classifier and GOST 2.201-80 can initially be converted to a class of recommended documents and then analysis of their introduction can be carried out within about 5 years. If there is a general need, they can be converted to compulsory documents. It has become evident that USSR Gosstandart must note many intersector systems of standards or convert them to the recommended standards, since the producers have not adopted them.

The situation must be taken into account in the USSR and there must be conversion of enterprises to cost accounting, self-supporting production [samookupayemost] and self-financing. The obligation to introduce all standards should be reviewed with regard to time requirements.

FOOTNOTES

1. Blinov, M. K., V. A. Bykov, A. A. Zykov et al., "On Introduction of GOST 2.201-80 and the YeSKD Classifier," STANDARTY I KACHESTVO, No 10, 1986, pp 35-39.

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UDC 621.7.07:025.4

ON CLASSIFIER FOR SPECIAL PRODUCTION RETOOLING

Moscow STANDARTY I KACHESTVO in Russian No 3, Mar 87 pp 57-60

[Article by A. L. Sinitsyna and M. Z. Usova]

[Text] One of the components of technological preparation of production (CPP) is the classification of retooling devices that permits one to solve a number of problems:

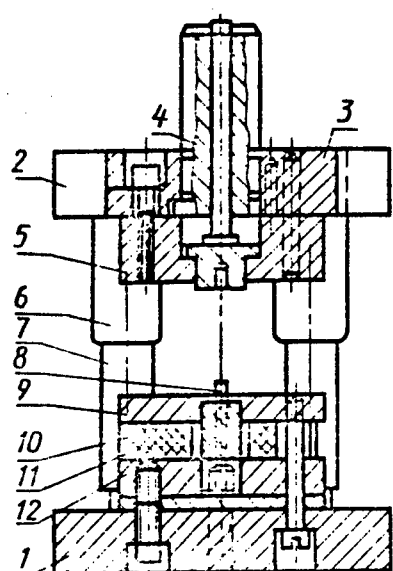
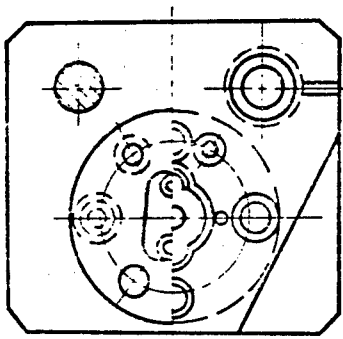
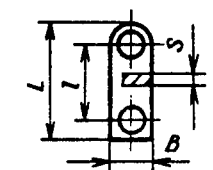
- to work out standard technological processes of manufacturing production equipment;
- to standardize production equipment;
- to accelerate design of equipment using computer hardware;
- to improve the processes of planning technological preparation of production and so on.

The classifier for blank-stamping equipment (ZShO) is used at our enterprise. Two forms have been developed for each standard representative of the equipment.

Form 1 contains the technical data about the standard representative: a drawing of the standard design of the equipment and of the part to be stamped; a verbal description of the design of the part, the code of the equipment according to YeSKD and the code of the equipment adopted at the enterprise.

Form 2 contains the technical and economic data about the equipment: mathematical models for computing the labor intensiveness of manufacturing the equipment (T_p) and the metals consumption (Q), a table of the production design features of the parts to be machined and tables of coefficients according to types of jobs and types of materials.

Form 1

Класс (1) 290000	(2) Оснастка технологическая	лист (3)																								
Подкласс (4) 294000	(5) Штампы	листои (6)																								
Группа (7) 294100	(8) Простого действия для разделительных операций																									
Подгруппа (9) (11) 294115 (по ЕСКД)	вырубки (10) (12) для плоских деталей комбинированного контура																									
(13) 10113 (по САВОН)	14) специализируемый, с направляющими колонками, с нижним эластичным съемником, круглой матрицей,																									
(15) ИПШ-1179 (прдпр)	(16) выталкиватель действует от прессы																									
  Эскиз (17) детали  УСЛОВНЫЕ ОБОЗНАЧЕНИЯ: (18) <table border="0"> <tr><td>1 - плита нижняя;</td><td>(19)</td></tr> <tr><td>2 - плита верхняя;</td><td>(20)</td></tr> <tr><td>3 - выталкиватель;</td><td>(21)</td></tr> <tr><td>4 - хвостовик;</td><td>(22)</td></tr> <tr><td>5 - матрица;</td><td>(23)</td></tr> <tr><td>6 - втулка;</td><td>(24)</td></tr> <tr><td>7 - колонка;</td><td>(25)</td></tr> <tr><td>8 - фиксатор;</td><td>(26)</td></tr> <tr><td>9 - съемник;</td><td>(27)</td></tr> <tr><td>10 - пуансон;</td><td>(28)</td></tr> <tr><td>11 - буфер;</td><td>(29)</td></tr> <tr><td>12 - пуансонодержатель</td><td>(30)</td></tr> </table>			1 - плита нижняя;	(19)	2 - плита верхняя;	(20)	3 - выталкиватель;	(21)	4 - хвостовик;	(22)	5 - матрица;	(23)	6 - втулка;	(24)	7 - колонка;	(25)	8 - фиксатор;	(26)	9 - съемник;	(27)	10 - пуансон;	(28)	11 - буфер;	(29)	12 - пуансонодержатель	(30)
1 - плита нижняя;	(19)																									
2 - плита верхняя;	(20)																									
3 - выталкиватель;	(21)																									
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9 - съемник;	(27)																									
10 - пуансон;	(28)																									
11 - буфер;	(29)																									
12 - пуансонодержатель	(30)																									

Key:

1. Class
2. Production equipment
3. Sheet
4. Subclass
5. Dies
6. Sheets
7. Group
8. Simple action for separation operations

(Key continued on following page)

9. Subgroup
10. Cutout
11. According to YeSKD
12. For flat parts of combined edge
13. According to SAVOK [not further identified]
14. Special, with column guide, with lower elastic connector and round die
15. IPSh-1179 (enterprise)
16. Ejector operates from press
17. Drawing of part
18. Notations
19. Bottom plate
20. Top plate
21. Ejection device
22. Shaft
23. Female die
24. Bushing
25. Column
26. Fastener
27. Puller
28. Male die
29. Buffer
30. Die holder

Mathematical models T_p and Q were found as a result of statistical processing of standard data for equipment of specific types, most typical for the examined enterprises. The mathematical models were developed by using the YeS-1022 computer according to special programs (LIRA and ISKRA) for processing the statistical data by the pair, partial and multiple correlation method. The mathematical models are expressed by a power function of type:

$$y = A_0 x_1^{a_1} x_2^{a_2} \dots x_i^{a_i},$$

where $x_1, x_2, \dots, x_i$ are the production design parameters of the part to be machined.

The range of permissible values of the part parameters is determined from the set of input data, on the basis of which the mathematical model is worked out.

The following correction factors were worked out for calculation of the labor intensiveness of manufacture of the equipment according to types of jobs:

$$K_i = \left\{ K_i = T_{pi}/T_p, \text{ etc.} \right\}$$

where K_T is the coefficient of labor intensiveness of lathe machining, K_ϕ is the coefficient of labor intensiveness of milling operations and so on and $K_{шл}$ is the differentiated labor intensiveness of manufacture by types of jobs.

Form 2

Класс (1) 290000	(2) Оснастка технологическая	(3) Листов													
Подкласс 294000 (4)	(5) Технико-экономические показатели	Лист (6)													
Группа 294100 (7)															
Подгруппа (8)	(12) МАТЕМАТИЧЕСКИЕ МОДЕЛИ РАСЧЕТА ТРУДОЕМКОСТИ ИЗГОТОВЛЕНИЯ И МЕТАЛЛОЕМКОСТИ ОСНАСТКИ														
Шифр по ЕСКД 294115 (9)															
Шифр чертежа предприятия (10)															
ИПШ-1179 (11)															
$T_{изг} = \frac{13,187 \cdot \epsilon^{0,227} \cdot \beta^{0,027} \cdot K_{ТСК}^{-0,0038} \cdot P^{0,151}}{Q}$ $Q = \frac{8,278 \cdot \epsilon^{-0,068} \cdot \beta^{-0,215} \cdot K_{ТСК}^{1,004} \cdot P^{0,282}}{Q}$															
(13) Конструктивно-технологические признаки обрабатываемых деталей															
(14) Область допустимых значений												Расчетные показате- (15) ли			
(16) ϵ		(17) β		$K_{ТСК}$		P		$T_{изг}$		Q					
от	до	от	до	от	до	от	до	от	до	от	до				
12	20	0,1	0,8	1	1,25	50	150			40	50	15	20		
21	40	0,9	1,2	1,3	1,5	151	300			51	65	21	30		
41	60	1,3	2,0	1,55	1,9	301	450			66	80	31	40		
61	85	2,1	3,5	1,91	2,0	451	500			81	110	41	55		
(18) Таблица коэффициентов по видам работ															
Токарные (19) K_T	Фрезерные (20) K_ϕ	Шлифоваль- ные (21) $K_{шл}$	Расточные (22) $K_{раст}$	Долбежные (23) $K_{долб}$	Строгаль- ные (24) $K_{стр}$	Слесарно-сбо- рочные (25) $K_{сл}$									
0,11	0,08	0,09	0,06	0,01	0,21	0,44									
$T_{оп} = T_{изг} \cdot K_i; K_i = \{K_T; K_\phi; K_{шл}; K_{раст}; K_{долб}; K_{стр}; K_{сл}\}$															
(26) Таблица коэффициентов по видам материалов															
Стали (27)				Цветные металлы и сплавы (30)				(31) Неметаллы							
(28) Углеродистые		(29) Конструкционные						Резина (32)							
$K_y = 0,7$		$K_k = 0,2$						0,1							
$Q_{эм} = Q \cdot K_{эм}; K_{эм} = \{K_{му}; K_{МК}; K_{МП}; \dots\}$															

(Key on following page)

Key:

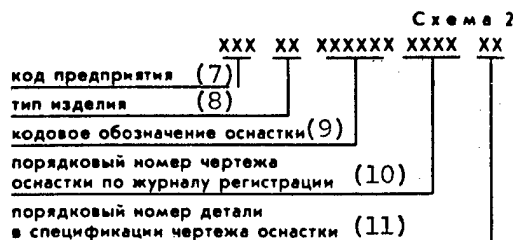
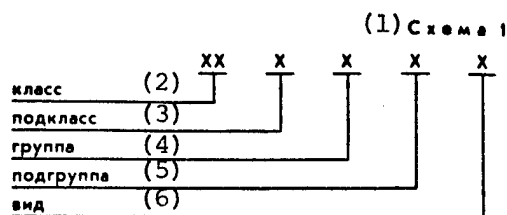
1. Class
2. Production equipment
3. Pages
4. Subclass
5. Technical and economic indicators
6. Page
7. Group
8. Subgroup
9. Cipher according to YeSKD
10. Cipher of enterprise drawing
11. IPSH-1179
12. Mathematical models for computation of labor intensiveness of manufacture and metal consumption of equipment
13. Production design features of parts to be machined
14. Range of permissible values
15. Calculated indicators
16. From
17. To
18. Table of coefficients according to types of jobs
19. Lathe
20. Milling
21. Grinding
22. Boring
23. Slotting
24. Shaping
25. Fitting-assembly
26. Table of coefficients according to types of materials
27. Steels
28. Carbon
29. Structural
30. Nonferrous metals and alloys
31. Nonmetals
32. Rubber

Correction factors according to types of equipment, calculated by the following formula, are given for calculating the required material for the equipment:

$$Q_j = Q K_{jm},$$

where Q is the number of the j -th type of material and K_{jm} is the coefficient of the type of material.

The error in calculation of the technical and economic indicators according to the mathematical models does not exceed 20 percent.



Key:

1. Scheme
2. Class
3. Subclass
4. Group
5. Subgroup
6. Type
7. Code of enterprise
8. Type of product
9. Code notation of equipment
10. Ordinal number of drawing of equipment according to registration log
11. Ordinal number of part in specification of equipment drawing

The YeSKD Classifier, class 29 "Production equipment, except cutting tool," was taken as the basis for coding the equipment. The text of the standard representatives of the equipment was described according to the YeSKD terminology and the Classifier of machine-building and instrument-building production operations. The facet-focus system of classification was used.

The structure of the code notation of the equipment was presented in scheme 1. The developed classifier contains 93 names of blank-stamping equipment.

The enterprise standard, used at the design office of the Cold Stamping Department during design of equipment and also the shaping services for determination of the proposed expenditures for the equipment during development of the product and according to the plant fabrication shops for determination of manufacturing expenditures was developed on the basis of the classifier.

An example of writing the notation of the equipment in the technical documentation according to the STP [not further identified] is given in scheme 2.

Introduction of the ZShR classifier at the enterprise made it possible to achieve a saving of 122 thousand rubles.

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COMPUTER-AIDED SCIENTIFIC RESEARCH SYSTEMS

Moscow NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA RADIOELEKTRONIKA I SVYAZ in Russian No 1, 1987 (signed to press 31 Dec 86) pp 1-64

[Booklet by Nikolay Vladimirovich Sinitsyn, candidate of technical sciences, lecturer, deputy chairman of the annual conferences on high sensitivity electronic and electromechanical devices and systems, Vladimir Petrovich Petropavlovskiy, candidate of technical sciences and Andrey Mikhaylovich Nikitin, engineer and senior instructor at the Moscow Order of the Red Banner of Labor Engineering Physics Institute, reviewed by V.A. Myasnikov, doctor of technical sciences, 51,950 copies, 64 pages]

[Text] Annotation

The brochure is devoted to a new area in science and engineering: computer-aided scientific research systems (ASNI), which are the highest stage of ASU [management automation system] control systems, ASU TP [plant technical management automation systems] and computer-aided design systems. Considerable attention is devoted to the computer hardware, interfaces as well as the procedural, database organization and management and software for scientific research. Design examples of Soviet and foreign computer-aided scientific research systems are discussed.

The brochure is intended for engineers, lecturers and popularizers, as well as readers interested in questions of enhancing the effectiveness of fundamental and applied scientific research.

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Introduction

The materials of the 27th CPSU Congress and the June Plenum of the CPSU Central Committee (1986) note that a fundamental acceleration of scientific and engineering progress based on revolutionary shifts, for example, a changeover to fundamentally new technological systems and to the latest generations of equipment that yield the maximum effectiveness, is being brought to the fore as the main strategic approach to the intensification of the national economy in the 12th Five-Year Plan. Primary attention here must be devoted to accelerating the development of computer technology, instrument making and electronics as the catalysts of scientific and engineering progress. It is altogether understandable that the questions posed here cannot be solved without the extensive development of effective fundamental and applied scientific research.

It is well known that the history of science is to no small extent the history of its tools. For this reason, the automation of scientific research that enables not only the automation of an experiment, but also the simulation of the object, phenomena and processes being studied, the study of which is either difficult or impossible by traditional methods, deserves special attention at the present time in order to enhance the effectiveness of science and its methods of understanding.

In this regard, considerable attention has been devoted in recent years in our country to the design of computer-aided systems for scientific research and comprehensive testing of samples of new equipment [1, 2, 3]. It should be noted that the application of computer-aided systems for scientific research (ASNI) and comprehensive testing of samples of new equipment is most effective in those fields of science and engineering that handle large volumes of data.

Computer-aided scientific research systems have a significant national economic impact by boosting labor productivity in research and design organizations, improving the cost effectiveness parameters of the objects being developed based on the use of more precise models for these objects as well as the elimination of expensive full-scale physical testing and certain stages of the prototype design work, which in the final analysis leads to a reduction in the developmental costs for new equipment and to a significant reduction in the time cycle from the origination of the scientific concept to its practical implementation in production.

Computer-aided research systems differ from other types of automation systems (automated control systems, plant technical management automation systems, computer-aided design systems, etc.) in terms of the nature of the information obtained at the system output. This information is primarily the processed or generalized experimental data; but the main thing is the mathematical models of the objects, phenomena or processes being studied based on these data. The adequacy and precision of such models is assured by an entire set of procedural, programming and other aids in the system. Ready-made mathematical models can also be used in computer-aided research systems to study the behavior of particular objects and processes, as well as to more precisely define these models themselves. For this reason, computer-aided research systems are

intended for generating, correcting or studying models which are then used in other types of computer-aided systems for control, prediction or design.

As a rule, all types of computer-aided scientific research systems are developed on the basis of the latest achievements of science and engineering in such fields as microprocessor computer hardware having an extensive set of peripherals (processors, disk and magnetic tape memories, printers, displays, etc.) and interface systems for interfacing the computer to the objects being studied. The procedural, program and database management support for scientific experimentation plays a no less important role in computer-aided scientific research systems. The hardware and software in computer-aided research systems perform the various functions of the preliminary data reduction, have a flexible and adaptive structure as well as maximum interchangibility of the modules and blocks, which are series produced in conformity with international standards. Computer-aided design systems are widely used in the design of computer-aided scientific research systems.

Problems and Ways of Improving the Efficiency of Scientific Research

A characteristic requirement that is placed on the modern scientist is a new type of economic thinking, the major aspects of which are the intensifying and accelerated placing in production of the latest achievements of science and engineering as well as the implementation of large, complex programs.

Things frequently worked this way in the past: a scientist did some kind of fundamental research and then a half a century later, and sometimes a hundred years later, this research underwent some further development and finally new materials and new technologies were created on the basis of it. Now, fundamental research is brought to life before our eyes in just a decade, and sometimes even within shorter timeframes. A new type of research is being born. When performing the research, the scientist already sees the possibilities for its practical realization, in particular in the economy. For this reason, such research is called purposeful, i.e. there is a definite purpose that must be realized at the end of each effort. Of course, even today there is research in which no definite purposes and results are seen. It goes without saying that such efforts must be made within the framework of fundamental research, but a definite place must also be made in this area for research with a practical outcome. This approach in science is creating a new way of economic thinking for the scientist, since purposeful fundamental research - the merging of theory and practice - is the bridge from the present to the future.

The views of scientists of the capability of using science in practice, linking science to manufacturing and the acceleration of scientific and engineering progress have changed markedly in recent times. Those who previously did not consider themselves to be linked to practical work, today advance the concepts of applied research themselves as well as thoughts of the practical utilization of the results of fundamental research. A fundamental break (and sometimes a painful one) and a change in the world view of modern scientists is manifest in this.

Science is successfully solving the most urgent problems in modern society in various fields of human activity, because of which, its development took an extensive approach up until recently. However, if the development of science had continued on at the same pace as before, then by the end of the 20th Century, the entire adult population of the industrially developed nations would have been absorbed by scientific organizations. For this reason, the phenomenon of so-called "saturation" or a limitation on the increase in the number of scientific personnel and organizations conducting scientific research has been observed recently in science. Moreover, the number of tasks and problems that are confronting scientists is increasing continually. Because of this, the problem has already arisen today of making the transition from extensive methods for performing scientific research to intensive methods. Thus, it has become necessary to sharply increase the effectiveness of the number and scope of scientific investigations through the wide scale utilization of scientific methods for organizing experimental and theoretical research and bringing automated systems on line that are designed around modern computer hardware. Therefore, given the "saturation" of science, the utilization of computer-aided scientific research systems for the performance of scientific experiments is the only approach to a fast developmental track for scientific research.

In order to gain a clearer understanding of the tasks and problems arising in the automation of scientific research, we shall consider several aspects of scientific understanding.

The process by which a human gains scientific understanding of the surrounding world takes place in close interaction between theoretical and experimental (practical) thought. The subject of an experimental investigation is a real object; the subject of a theoretical investigation is some model of the studied object. Theory and experiment are the two facets of human scientific activity, the basic goal of which is practice and the public production of physical assets. V.I. Lenin, underscoring the exceptionally great importance of practical activity, noted that at particular points in time in historical development, "theory is transformed into practice, is brought to life by practice, is corrected by practice and tested by practice . . ." ("Complete Collected Works", Vol 35, p 202).

Experiment plays an important part in the process of scientific thought. Figure 1 shows the general functional configuration of an experimental research system. The subject of an experimental study (the subject of the work) is the studied object having unknown properties using technical means (the tools of labor) - the experimental equipment, that makes it possible to have different kinds of physical and chemical effects on the object; also used are the instrumentation which records and registers the response of the interaction between the studied object and the experimental equipment as well as the experimental data processor. At the center of the experimental investigation is the human experimenter, who determines the functioning of the entire research system.

The goal of an experiment consists in the trial study of the unknown properties of the object of the investigation and the construction of a physical

(descriptive) model and a mathematical model of the object. The available theoretical knowledge or preliminary experimental data on the object are used as the apriori information when selecting the structure of the mathematical model of the object.

The experimental investigation procedure includes the formulation of the research task (the definition of the object and the research goals), the development of the experimental procedure, the selection of the experimental equipment, the development of the experimental plan, drawing up the program for the execution (realization) of the experiment, setting up the experimental equipment, checking the operability of the experimental hardware, performing tests in accordance with the specified program, the collection and processing of the experimental data, the interpretation and discussion of the processing results, the completion of the reporting documentation (explanatory text, tables, graphs and figures) as well as the transmission of the reporting documentation to the scientific center and the search for further research directions.

Along with the concept of a "physical experiment", the new concept of a "computer experiment" has recently appeared [19, 20]. The fact is that the execution of a program on a computer is similar in many regards to the conduct of an experiment. However, in contrast to a physical object in an ordinary experiment, the objects in a computer experiment are not constrained by the laws of nature, but rather obey laws expressed by means of the computer program. Thus, computation expands the sphere of experimental science: it makes it possible to conduct an experiment in some hypothetical (conjectural) domain. Computation also expands the theoretical research as well. By tradition, all scientific laws are described by mathematical functions and constructs. At the same time, a scientific law defined by means of an algorithm, can nonetheless take on any noncontradictory form. For this reason, it has become possible to study a number of complex systems that were previously not subjected to investigation by traditional mathematical methods, but now computer experiments or the analysis of computer models is employed.

Thus, for example, it is not difficult to think up a laboratory experiment in order to study the trajectory of motion of an electron in the magnetic field of a television tube. However, there is no laboratory experiment that will be able to reproduce the conditions under which an electron moves in the magnetic field of a neutron star. A computer program can be used in both cases though.

By way of illustration, we shall consider the investigation of the random motions of polymer molecules (motions without any crossings) using computer methods (Figure 2). Such random motions serve as the model for such physical processes as the packing of polymer molecules, and differ from the usual random motions in that each step must not intersect the preceding paths. Therefore, it was impossible to set up a simple differential equation in this case, and the properties of such random motion were investigated by means of direct simulation using a computer.

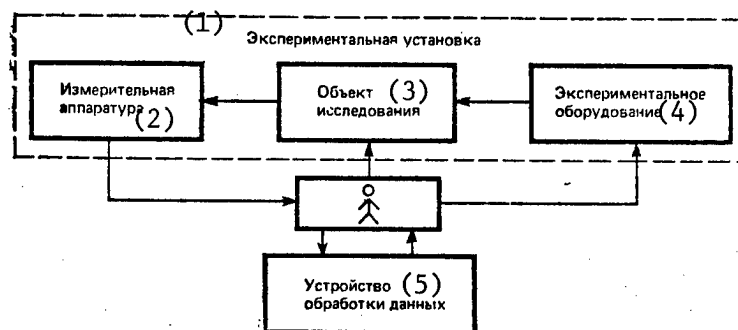


Figure 1. Block diagram of a system for experimental studies.

Key: 1. Experimental set-up; 4. Experimental equipment;
2. Instrumentation; 5. Data processor.
3. Object of the study;

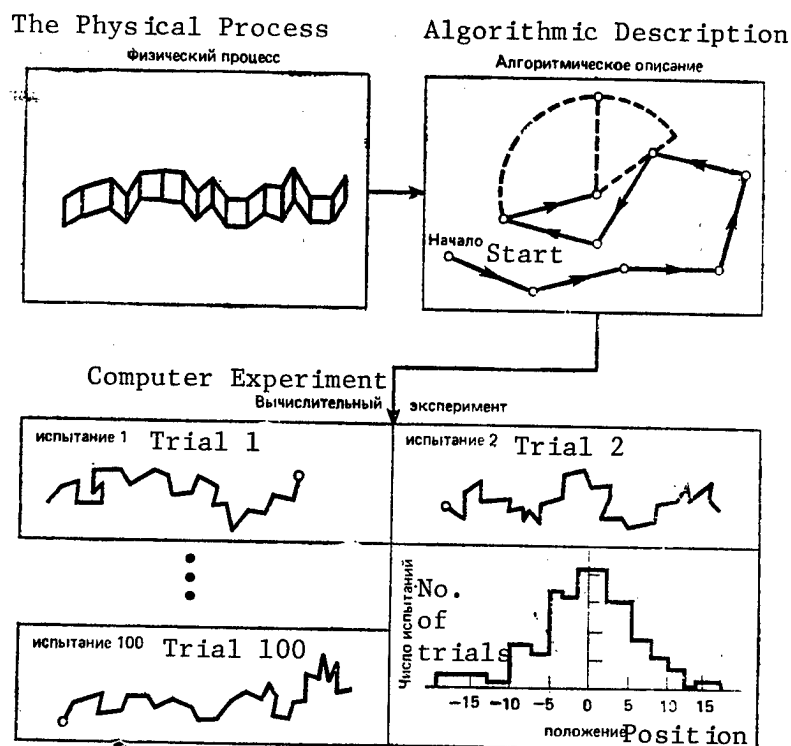


Figure 2. Study of the random motions of polymer molecules by means of a computer experiment.

Thus, the computer experiment has become a new and powerful tool that has supplemented previously existing procedures of theoretical and experimental science.

The application of scientific planning methods for experiments and the automation of the experimental studies using modern automation and computer hardware has become a no less important way of boosting experimenter work efficiency and quality.

Just a few decades ago, questions of the organization of a scientific experiment were fully and independently solved by the experimenter himself, i.e. there were no standardized rules for planning an experiment, processing its results, etc.

In this case, in studying comparatively simple objects, the scientist has adhered to the concept of a "pure experiment", in which all outside influences have been excluded right at the outset. At the present time though, a scientist must deal with complex objects and systems, which are influenced by a large number of interrelated factors that differ both in nature and the extent of their effect. For this reason, multifactor experimental investigation of the objects being studied and the optimization of the experiment, i.e. the formulation of the experiment on a scientific basis has become a necessity (Figure 3).

In the early stages, when processing the scientific research data, scientists optimized the mathematical and statistical analysis procedures, as a result of which, there appeared the method of least squares, the principles of regression and correlation analysis as well as the concept of small samples. All of this made it possible to obtain quantitative evaluations of an experiment. However, in the case of a poorly formulated experiment, not even the very best mathematical data processing will be able to have an effect. The young statistician R. Fisher (1890-1962, U.S.) successfully found a way out of the resulting situation in 1919; he subsequently established the fundamental mathematical theory for the design of experiments [4]. He proposed that scientists intervened in the process of the formulation of the experiment, and were not limited just to the processing of the data.

The following concepts were used as the basis for experiment design theory: randomization (random order for the execution of the trials), repetition of the trials (in order to increase the measurement precision) and the partitioning of the experiment plan into units (the exclusion of interfering factors).

Experiment design theory found broad support among experimenters. Thus, special plans (fractional replicates) were used subsequently for the optimal reduction in the process of sorting through the variants of the trials to be performed, and in 1951, the method of steep ascent was proposed as an extremum search procedure; this method became the most widely disseminated in our nation. The American mathematician D. Kiefer developed the fundamentals of plan optimality theory in 1959; these were successfully adapted to the solution of practical experimentation problems by the Soviet scientist V.V. Nalimov using the theory of quasi-D-optimal plans [5]. However, the problem of the computer-aided design of such plans arose in this case; this was successfully solved by another Soviet scientist V.V. Fedorov. A new field appeared in the 1970's, known under the name of data analysis and linked to the name of the American mathematician J. Tukey. The essence of the method consists in a new approach instead of the traditional method of fitting the actual task to one of the well-known theoretical schemes of the "linear model, normal distribution" type: "for each existing set of data, find a scheme (system of prerequisites) that best conforms to both this data set and to everything known to us about it." Consequently, the data file can be processed as long as desired using subsamples of various sizes, different models and processing techniques.

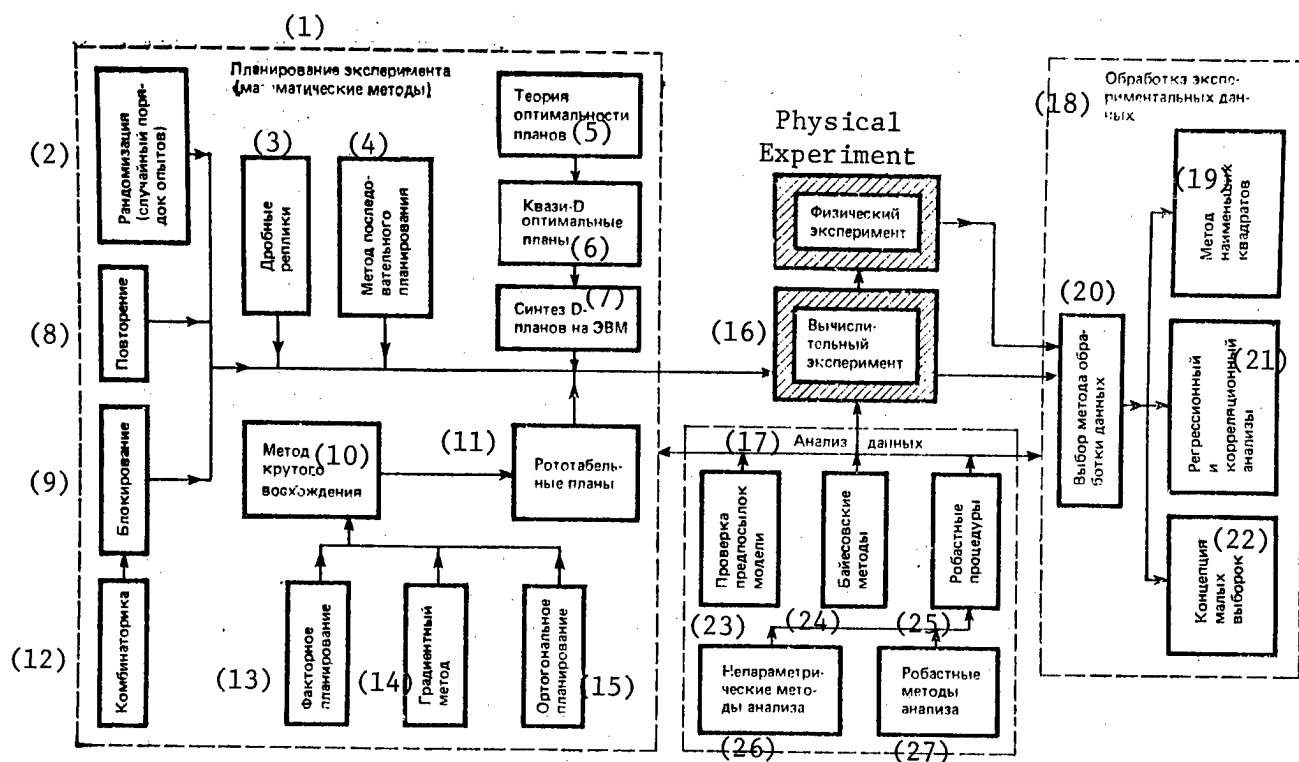


Figure 3. Scientific methods for the design and conduct of a physical experiment.

- Key:
- | | |
|---|--|
| 1. Designing the experiment (mathematical methods); | 17. Data analysis; |
| 2. Randomization (random order of the trials); | 18. The processing of the experimental data; |
| 3. Fractional replicates; | 19. Method of least squares; |
| 4. Sequential planning method; | 20. Selection of the data processing method; |
| 5. Theory of design optimality; | 21. Regression and correlation analyses; |
| 6. Quasi-D-optimal designs; | 22. The concept of small samples; |
| 7. Computer-aided design of D-plans; | 23. Checking the model prerequisites; |
| 8. Repetition; | 24. Bayes methods; |
| 9. Blocking; | 25. Robust procedures; |
| 10. Method of steep ascent; | 26. Nonparametric analysis techniques; |
| 11. Rotatable plans; | 27. Robust analysis methods. |
| 12. Combinatorial analysis; | |
| 13. Factorial design; | |
| 14. Gradient method; | |
| 15. Orthogonal planning; | |
| 16. Computer experiment; | |

This means that any scientific research formulated without the recommendations of the mathematical theory of experimentation cannot be called scientific. This research must include the preliminary planning, processing of the results and the interpreting of the data.

New governing laws and aposteriori hypotheses are developed on the basis of a comparison of the results of the theoretical and experimental research; these laws and hypotheses are used in fundamental and applied areas in the development of science.

The major steps in the performance of scientific research are shown in Figure 4.

The implementation of mathematical methods of experiment design in scientific research practice in the USSR is being publicized by the section on "Mathematical Experimentation Theory" of the Scientific Council on the Comprehensive Problem of "Cybernetics" of the USSR Academy of Sciences, headed up by doctor of technical sciences V.V. Nalimov. Moreover, lecture courses on the automation of experiments and scientific research are presently being given in many of the nation's higher educational institutions (Moscow Order of Lenin Power Engineering Institute, Moscow Order of Lenin and Order of the Red Banner of Labor Chemical Engineering Institute imeni D.I. Mendeleyev, Moscow State University, Moscow Order of the Red Banner of Labor Engineering Physics Institute, etc.).

An important factor in the design of systems for computer-aided scientific research and their operation is the mathematical training of the scientific and engineering personnel. This is related to the fact that mathematics has become of such great importance in the life of society in our time that the current period is spoken of everywhere in the world as the period of the mathematization of human activity. It was noted above that mathematics is not only a means of processing scientific research data, but also a tool for designing the scientific experiment, for which it is necessary to construct a mathematical theory of experimentation beforehand. Because of this, the following knowledge in the field of mathematics is required of the computer-aided scientific research system engineering specialist: probabilistic methods, including probability theory, mathematical statistics, coding and information theory, optimization techniques, methods of discrete mathematics, consisting of set theory, the theory of automata, graph theory, mathematical logic, the theory of algorithms and recursive functions as well as mathematical linguistics and combinatorial analysis.

The term discrete mathematics is due to the fact that there is no concept of continuity and differentiability in it. It is needed in order to describe discrete processes which are practically impossible to describe by means of the tools of continuous mathematics (differential equations). It should be noted that while the first subject area is studied in sufficient detail in the higher engineering schools, the training in the second area is as yet inadequate.

One of the social and psychological factors in the scientific and engineering revolution is the fact that the modern generation of engineers has gained markedly from the progress in the natural sciences as compared to specialists who were educated 10 to 15 years ago. Specialists of the older generation were carriers of experience in earlier times. It was assumed that the longer a person lives, the more he knows. The volume of information today has grown

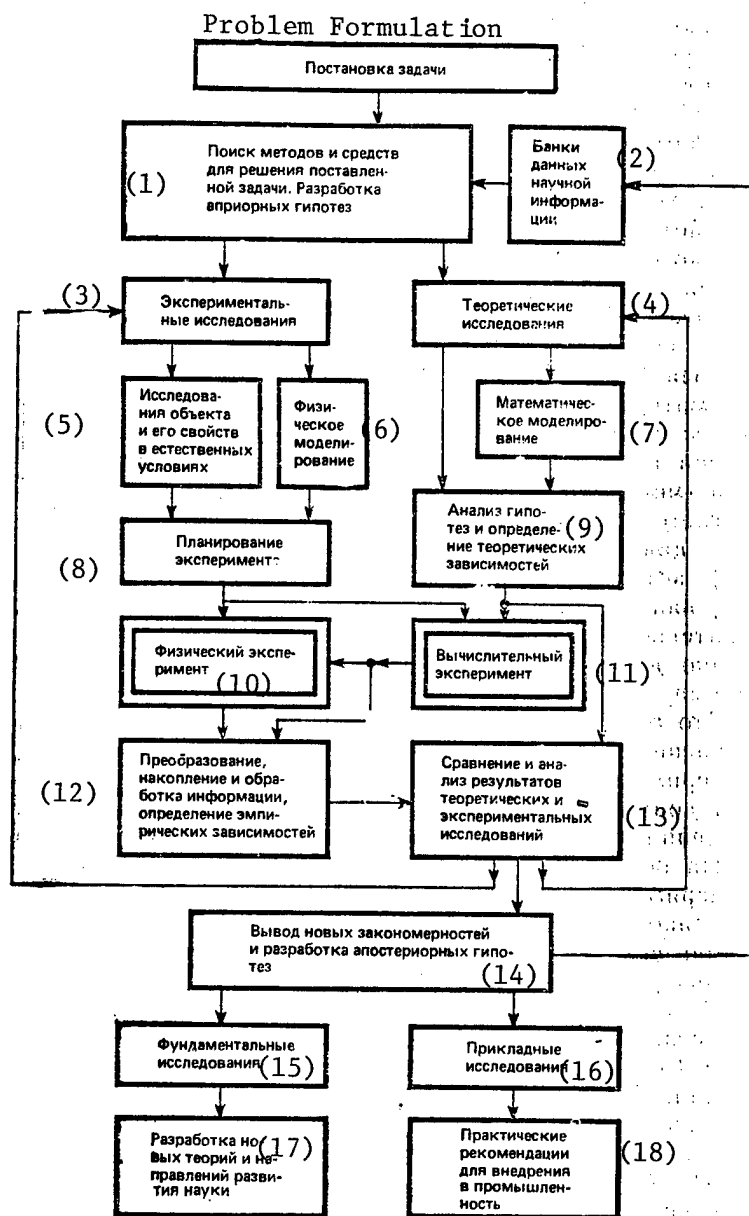


Figure 4. The major steps in scientific research.

- Key:
- | | |
|---|---|
| 1. Search for the methods and means of solving the problem posed. The development of a priori hypotheses; | 8. Designing the experiment; |
| 2. Scientific databases; | 9. Analysis of hypotheses and the determination of the theoretical relations; |
| 3. Experimental research; | 10. The physical experiment; |
| 4. Theoretical research; | 11. The computer experiment; |
| 5. Investigations of the object and its properties under natural conditions; | 12. Conversion, storage and processing of the data; the determination of the empirical functions; |
| 6. Physical modeling; | 13. Comparison and analysis of the results of the theoretical and experimental research; |
| 7. Mathematical simulation; | |

Key to Figure 4 [continuation]:

14. Derivation of new functional laws and the development of aposteriori hypotheses;
15. Fundamental research;
16. Applied research;
17. The development of new theories and areas of scientific development;
18. Practical recommendations for implementation in industry.

so much that no single specialist can assimilate all of the requisite information. A scientist today is not the one who remembers a great deal, but rather the one who seeks, finds and creates new information. However, the mind of the older generation of specialists is wisdom. Wisdom is a quality not identical to intelligence; it is born at the junction between intelligence, experience and moral sensibilities. The practice of the collective form of creative labor, which combines the wisdom of the older generation of engineers with the energy of young scientists, which has come into being of late also follows from this.

The considerable successes achieved in relatively short periods of time in such advanced areas of science and engineering as electronics and computers have generated a number of problems in the education system. For example, while aviation in the past 80 years has gone through 4 generations of aircraft (beginning with the flying "bookcases" and ending with spacecraft), electronics has also gone through 4 generations of the component base in just the last 20 years alone, where the first generation was based on vacuum tube circuitry and the last (the fourth) on microprocessor systems. For this reason, the problem of training and retraining personnel in the field of microprocessors and microcomputers, which are the basis for modern computers, electronics and automation, has become particularly acute at the present time.

Another problem, as the academician A.P. Aleksandrov has noted many times, is the marked lag behind the leading nations in the field of computer engineering and automation. This problem will be solved at the highest modern level in the next two to three years. However, the computer hardware that has come into being in our country, in terms of its rate of growth, is beginning to outstrip both the training of personnel and the computer software. The problem of eliminating the lag in the development of computer engineering and the formation of a unified mathematical and engineering policy as well as a personnel training policy arises in this regard. It is important to train not only the youth, but also the older generation in this case.

Considering the importance of the problem posed here, measures to assure computer literacy for students in intermediate educational institutions and the wide scale introduction of computers in the instructional process were defined at a number of sessions of the Politburo of the CPSU Central Committee. The CPSU Central Committee and the USSR Council of Ministers adopted a decree concerning this question that provides for the introduction of the course "Fundamentals of Computer Science and Engineering" starting in 1985 in all of the nation's intermediate educational institutions. Considerable experience in teaching the fundamentals of programming in intermediate educational

institutions has been acquired in our nation. Thus, as early as 1960, this subject was introduced in Moscow Secondary No. 444 as an experiment. For this reason, such schools have also appeared in Zelenograd and Barnaul, and there are now more than 300 of them in the nation. The training of school students in the programmer and operator specialty is underway in many industrial training centers. Thus, for example, electronic computer engineering is being taught in Moscow at 15 industrial training centers (UPK), while the students get on-the-job training in the computer centers of the host enterprises.

The contents of the new course were developed in accordance with one of the main principles for the reform of the general educational and vocational schools. The following is to be emphasized in this case: the mastery of programming methods and languages is not a goal in and of itself, but rather a practical means for solving problems with computers. The main requirement of computer literacy is the training of students for the application of computers in their later practical activity. The course program has been developed and a textbook has been written; in this case, all of the mathematics and physics instructors have gone through training in special seminars and courses. No less than 50,000 departments of computer science will be created in the schools, while hundreds of thousands of computers are to be directed into the educational sector.

Work is now under way on the selection of the most suitable computers for our schools, taking into account foreign experience with computer instruction in Great Britain, France and Japan. Our specialists are also faced with setting up the software and procedures for the instructional process as well as preparing packages of various applied programs in all fields of knowledge. The task has been set of making the computer a reliable assistant not only in the study of the natural sciences, but also the humanities. One of the most important tasks is that of finding ways of using microcomputers in on-the-job training and their application to work outside the classroom (clubs, Pioneer Clubs, Palaces of Culture, etc.).

They are trying to solve this problem in the capitalist nations as follows though. Many Western companies are proposing pensioning off the generation of 40 to 45 year old engineers who have not mastered computer engineering, i.e. dump them overboard, instead of training them on the new hardware and in the new methods of labor [7]. At the same time, serious steps are being undertaken in the West to teach schools students the fundamentals of computer programming. Thus, for example, in accordance with the legislation passed by the U.S. Congress under the name "The Children Cannot Wait" (The Technology Education Act of 1982, No. 5573), it is planned that 103,000 "Apple" personal computers will be placed in the school classrooms of the U.S. American sociologists anticipate significant socioeconomic changes in the nation because of the appearance in the near future (five to seven years from now) of the first generation of intermediate school graduates and colleges of the era of "thorough computer literacy". It follows from this that computers are fundamentally transforming the labor of scientists, whose major efforts in this sense will be directed towards the development of algorithms and programs for simulating objects and their properties, as well as towards the

automation of scientific research. According to forecasts of American companies involved in the manufacturing of computer hardware, more than 30 million engineers in the U.S. will have to be engaged in the development of algorithms and programs for solving scientific and production problems by the end of the 20th century [7].

The Major Functions and Structure of Computer-Aided Scientific Research Systems

An ASNI [computer-aided scientific research system] is a man-machine system that in the general case solves the problems of the theoretical simulation of the studied object, as well as planning, implementing (performing), monitoring and controlling the experiment and processing the experimental data and comparing it with the theoretical results.

The scientist who puts forward the hypothesis and formulates the research task also designs the experiment in an ASNI. Then he selects the methods and ways of executing the tasks, monitors the course of the experiment, and based on an analysis of the data obtained, corrects the experiment and draws conclusions, indicating recommendations and directions for further research. The following functions are assigned to the ASNI in this case: the simulation of the object being studied; adjusting and testing the performance of the experimental set-up; implementing the programmed control of the course of the experiment; the retrieval, display, recording and storage of the experimental data; the completion of the reporting documentation in both alphanumeric and graphic form and the transmission of the data to the scientific center.

Computer-aided scientific research systems consist of subsystems and components that are joined together by a number of standard procedures. We shall consider the basic definitions of the systems, subsystems, components and procedures in an ASNI (Figure 5).

A computer-aided system for scientific research and comprehensive testing of samples of new equipment is a software and hardware system based on computer tools intended for the conduct of scientific research or comprehensive testing of samples of new equipment based on the generation and utilization of models of the objects, phenomena and processes being studied.

The software and hardware complex of an ASNI consists of the procedural aids, software, hardware, database management system as well as the organizational and legal support. The interaction between the object, phenomena or process being studied and the ASNI is realized through the interface equipment, incorporated in the software and hardware complex. The interaction of scientific research organizations or enterprises with the ASNI is regulated by means of the organizational and legal support for the system.

It must be noted that the testing of objects, phenomena and processes, as well as the generation and investigation of the mathematical models are accomplished by means of user interaction with the ASNI in an interactive mode. For this reason, automatic procedures can be executed in an ASNI; in such procedures, the data processing and the identification or construction of the mathematical models are accomplished without human participation.

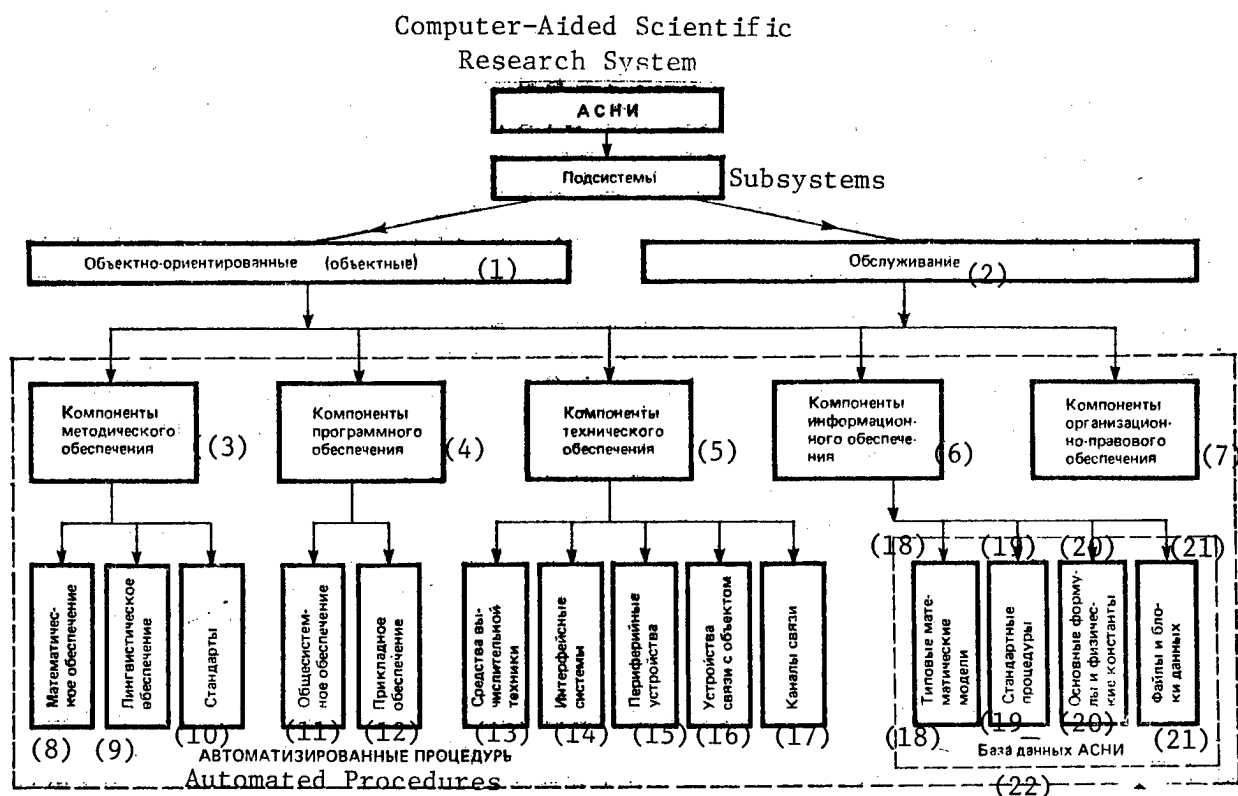


Figure 5. The interrelationship of subsystems, components and procedures in an ASNI [computer-aided scientific research system].

- Key:
- | | |
|---|---|
| 1. Object-oriented subsystems; | 13. Computers; |
| 2. Operating subsystems; | 14. Interface systems; |
| 3. Procedural support components; | 15. Peripherals; |
| 4. Software components; | 16. Interfaces with object; |
| 5. Hardware components; | 17. Communications channels; |
| 6. Database organization and management components; | 18. Standard mathematical models; |
| 7. Legal organization support components; | 19. Standard procedures; |
| 8. Algorithms; | 20. Fundamental formulas and physical constants; |
| 9. Linguistic support; | 21. Data files and modules; |
| 10. Standards; | 22. Database for the computer-aided scientific research system. |
| 11. General system support; | |
| 12. Applied software; | |

The major structural components of an ASNI are the subsystems. The portion of an ASNI that supports the execution of particular computer-aided research (or test) procedures and the generation of the appropriate output documents, where this portion of the ASNI is defined in terms of certain attributes, is called an ASNI subsystem. Computer-aided scientific research subsystems are broken down into object-oriented and operating subsystems.

An object-oriented subsystem obtains and processes the experimental data from some object. The object may be the experimental data processing subsystems for data obtained from special installations (accelerators, spectrometers, test stands), ships, seismic survey systems or collective-use systems for a group of homogeneous experimental installations or stands.

An operating subsystem performs the data processing and control functions that are independent of the particular features of the phenomenon, object or process being studied. The operating subsystems include the subsystems for ASNI control, interactive procedures, numerical analysis, design and optimization of the experiment as well as the input, processing and output of the graphics information and the information retrieval procedures.

An ASNI subsystem consists of components joined together by a procedure common to the given subsystem. An element of the support aid that performs a particular function in the ASNI subsystem is called a component.

It must be noted that the structural unity of an ASNI subsystem is assured by the linkages between the components of the various support aids forming the subsystem, while the structural integration of the ASNI subsystems into a system is assured by the linkages between the components incorporated in the subsystems.

The ASNI support aids include the procedural, software, hardware, database organization and management as well as organizational and legal support components.

The design of any system starts with the choice of its structure, the hardware components and the determination of their interrelationship. Electronic computer systems are included as one of the major standard components of ASNI hardware; these systems consist of a processor, main memory, input/output channel, data exchange processor, display, data display peripherals, data input peripherals and control actuation devices (mechanisms). The ASNI communicates with the objects being studied by means of the instrumentation hardware and the interface systems. Communications between ASNI's are accomplished by means of data transmission hardware and systems (interface communications processors) as well as communications channels. Data accumulation is supported by data storage and recording peripherals (and data banks).

Data input and output peripherals that display and record the data form the hardware system called terminals. Terminals with data transmission equipment, including processors and communications channels form the class of remote terminals. A terminal complex and a computer with special software is called an intelligent terminal. Control instrumentation and actuation hardware intended for data exchange between computers and the experimental facility form a class of special purpose terminals, in contrast to general purpose terminals for data exchange between a person and the computer.

Depending on the form of data representation, all hardware is broken down into digital and analog. Recently, because of the rapid development of micro-electronics and computers, data transmission and processing are accomplished, as a rule, in digital form.

Depending on the nature of the arrangement of the components, ASNI's are broken down into systems with lumped components (local ASNI systems) and systems with distributed (remote) components.

Depending on their purpose in an ASNI, a distinction can be drawn between standard subsystems for experimental data collection, data processing, real-time control of the experiment and the automation of the scientific calculations and modeling.

The structure (configuration) of an ASNI is determined by the set of tasks to be executed, the hardware composition of the system and the arrangement of the information sources and recipients. Nodal, chain, common bus, hierarchical (multilevel) radial and network structures have become widespread in the class of standard structures for ASNI systems.

In the general case, the configuration of system structures may be the most diverse, including those consisting of a combination of the standard structures treated above. Bus and hierarchical structures, which are the ones most often used in ASNI's, have the greatest flexibility.

One of the important design steps is the analysis of ASNI cost-effectiveness, which is carried out for the purpose of substantiating the expediency of capital investments in the ASNI and the selection of its optimal structure, based on a comparative analysis of the organizational variants for the ASNI and the planning of the economic management activity of the subdivisions, taking into account the national economic impact. It is necessary in this case to determine the dimensions of the material incentives for the ASNI personnel in order to accelerate the pace of system implementation, expand the applications area and improve the operational quality of the ASNI, and also develop the original standards for establishing the cost-accounting relations between the ASNI and the users for the purpose of economically validated management of the process of ASNI design and development.

Scientists usually work from a comprehensive accounting for the influence of all factors of ASNI effectiveness, a complete consideration of all costs, the equality of ASNI costs and results in terms of the time needed to achieve these results as well as the comparability of the costs and results in terms of the industrial impact when analyzing the cost-effectiveness of computer-aided scientific research systems.

In order to determine the national economic and socioeconomic impact of an ASNI, the influence of all of the factors governing the effectiveness of such a system are taken into account; these can include the reduction in the time-frames for the performance of the experiments, the decrease in the labor intensity of the scientific research, the improvement in the quality of the scientific data and the increase in the fixed capital loading indicators. The analysis also includes the possibility of setting up the experiments without using automation, substituting the simulation of the actual conditions for expensive full-scale testing and breadboarding as well as improving the working conditions of the personnel engaged in the performance of the experiments.

In order to fully account for all of the costs involved in an ASNI, it is necessary to analyze the change in the expenditures (capital investments and current operating costs) in those sectors of the national economy as well in which the results of the scientific research from the ASNI are employed.

The consistent expansion in the application of automation to scientific research presupposes the possibility of developing computer-aided scientific research systems by bringing additional components into play, which leads to a time spread in the cost structure. Since costs incurred at different times cannot be considered of equal economic importance, they must be reduced to a single point in time in order to establish the equality of the costs and results of ASNI implementation. In the analysis of ASNI cost-effectiveness, comparisons are drawn between the organizational variants for the scientific research that differ in terms of the size of the industrial impact, the volume of processed data and the number of experiments performed. This necessitates the reduction of the costs and data for the variants to a comparable form, which is accomplished by introducing "equivalent objects" into the calculations that equalize the industrial impact, or all of the economic indicators are calculated using a proportionate share expression.

Hardware and Software for Computer-Aided Scientific Research Systems

The hardware for computer-aided scientific research systems are based on the State System of Automation Aids and Instruments (GSP) developed in the USSR; this system includes transducers, measurement instruments, control devices, actuating mechanisms, interface systems, data transmission equipment and computer hardware, as well as the YeS and SM computers and microcomputers.

A no less important component of the ASNI's being developed is the computer software for them; this software is defined as the programs, methods and instructions intended for the execution of the scientific tasks, system control and the servicing of the users during the course of the programming, the debugging and running of the programs.

Depending on the functions performed in a computer system, two constituent parts have come to be discriminated in the software:

- The operating system, OS, which is intended for the efficient organizing of system operation during the execution of the tasks;
- Special purpose software, oriented towards the direct execution of user tasks.

The operating system of modern computers is usually broken down into the control program and the programming system. The control program organizes the computing process when solving applied problems, controls the hardware of the computer system and supports its specified operating mode. The programming system includes the software for automating the process of debugging the user programs.

Hardware for Computer-Aided Scientific Research Systems

Computers are included among the most important multiple function components of ASNI hardware. Computer hardware determines the direction of the development of automation systems for various purposes. Modern ASNI's can be constructed only on the basis of the extensive use of computers (for executing the following tasks: simulation, experimental data processing, data exchange, system organization, system interaction with a human operator and a number of other tasks).

It must be noted that the computer is a tool for amplifying the natural capabilities of human intelligence. The meaning of this can be illustrated by means of a simple analogy. It is well known that of the 100 species of animals, arranged in order of their level of efficiency with which they use muscle power for motion, the condor can be placed in first place while man is in the bottom third of the list. At the same time, a man riding a bicycle is many times more efficient than the known animals, including even the condor, in terms of the muscular energy utilization efficiency; a computer performs the same tool functions of boosting efficiency for a scientist as the bicycle does, but in another area: in the intellectual sphere of human activity. In this instance, the computer does not equalize the intellectual capabilities of people (as for example an automobile does in the case of travel), but only amplifies the efficiency with which the scientist utilizes his natural data.

We shall discuss the trends in the development of modern computers in order to gain an idea of their capabilities in ASNI applications.

The period of the rapid development of modern computers began in the 1950's, when the first series produced electronic computers were built both in the USSR and abroad; the use of these computers subsequently led to a technical turnaround and was one of the stages in the modern scientific and technical revolution.

A number of generations can be noted in the history of computer development; these generations differ not only in the qualitative and quantitative jumps in the component base, but also in their performance, cost and functional purpose.

Starting with the use of the first generation machines and programmable instruments (spectrum analyzers, correlators, etc.), modern ASNI's are oriented towards the use of third and fourth generation computers. Considerable research is under way at the present time in the development and design of optronic computers based on optical processors. The use of such machines will make it possible not only to increase the volume of processed data by many times, but also sharply increase the computer speed. Moreover, the use of optical data transmission channels in computers will make it possible to eliminate what is called by specialists the curse of the "rat's nest" - the multiconductor bundles of electrical wires which can be replaced with a single conductor: a fiber optic lightguide. In this case, the information being processed in parallel in the computer is transmitted sequentially

through an optical communications channel at a rate of up to 1,000 MHz and more.

The development of the nationwide distributed and local area computer networks, tied into international information databases will make it possible to boost ASNI efficiency when obtaining scientific and technical information, which is a new kind of product at the present time. In this case, the structural design of multimachine systems may be both hierarchical (large, small and micro-computers) and homogeneous (using computers of a single class), and in this case, the operation of homogeneous networks in a hierarchical system is not precluded. The recent appearance of scientific instruments with built-in microcomputers [6] which have come to be called intelligent (Figure 6) should also be noted.



Figure 6. Program-controlled optical reflectometer.

Until recently, specialists have defined the developmental level and directions in computer engineering primarily in terms of hardware performance. However, because of the fact that considerable attention is being devoted to the economic indicators of computers in science and technology, considerable interest is generated by the cost criterion used for classifying computers and proposed by academician B.N. Naumov. In this case, machines costing more than 250,000 rubles are considered to be large computers, medium computers are those costing from 50,000 to 250,000 rubles and small computers are those costing less than 50,000 rubles. In turn, minicomputers whose cost does not exceed 20,000 rubles and microcomputers costing less than 5,000 rubles are discriminated within the class of small machines. Naturally, with the course of time, the boundaries between the various computer classes will change, since the integrated circuit manufacturing technology is being improved continually and the cost of minis and micros is decreasing. However, the appearance of the modular bus computer design principle has enabled the user to develop special purpose computer systems with the requisite and in no way limited number of peripherals, the cost of which basically determines the computer cost. For this reason, it is more expedient to use computer function as the classification criterion.

We shall deal in somewhat more detail with the "personal computer" phenomenon that appeared a few years ago (Figure 7). It must be noted that the personal computer is already in the U.S. today for an engineer the same prestigious thing that the six-shot Colt [revolver] was for a resident of the American West in the past century, where the Colt was called the great equalizer. Similar to the Colt, the personal computer enables the engineer to "arm" his intelligence so as to be able to play "on a par" with his colleagues.

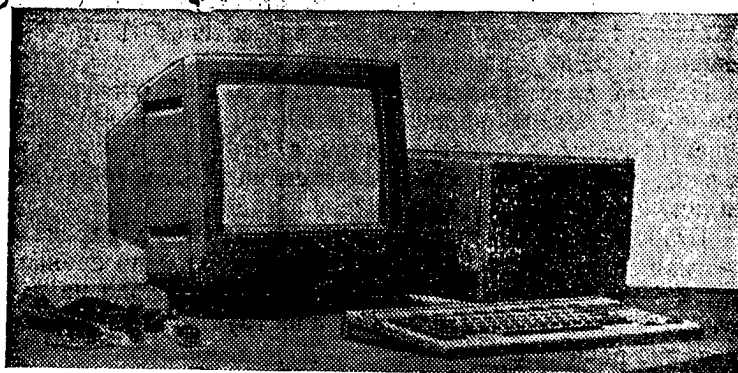


Figure 7. Personal computer.

The considerable diversity in the various types of computers that have appeared relatively recently, and the lack of the necessary information in a number of cases, is causing certain difficulties among specialists when selecting computers for computer-aided research systems.

While a scientist's choices are rather limited in the field of large computers and the user primarily works with particular models of YeS computers that differ only in their performance and have practically only one operating system, the OS YeS, such a diversity of hardware and software incompatible models is observed in the area of minicomputers and microcomputers that it is difficult even for the specialist to select the most suitable machine for an automated system. In this case, the designer of an ASNI must provide for the hardware and software compatibility between the large, small and micro-computers used in the designed systems and the systems with which the ASNI may be linked within the framework of information networks. For this reason, the authors feel that it is necessary, without going into the details, to provide the reader with a so-called "Ariadne's thread", so that he can get around relatively freely in the indicated computers.

Operational experience with the YeS computers, the necessity of the universal introduction of computers in automated control systems, plant management automation systems, etc., as well as the use of computer hardware in scientific experimentation directly at the object of study are responsible for the fact that CEMA member nations created the International System of Small and Micro-Computers (SM EVM) in the second half of the 1970's (Figure 8).

Two stages are ascertained in the developmental program for the SM computers. The first stage (1975 to 1978) had as its result the development of the base

series of processors, the SM1 and SM2, the SM3 and SM4, with an extensive set of software and peripherals [8, 9]. In the second stage of the program (1978 to 1983), the make-up of the SM computer models was selected taking into account the requirements placed on minicomputers and microcomputers in the largest applications areas of the computers.

The subsequent program for the development of the SM computers has been worked out (the third stage of the SM computers), in which special attention is being devoted to the development of the hardware and software for the construction of so-called local area networks and for the interfacing of various types of computer networks, which will make it possible to create multilevel network systems.

The program of the second stage provides for the creation of five new classes of computer models that assure the greatest cost-effectiveness of the application of SM computers in the national economy.

The first model class of the second stage of the SM computers is the low performance SM50 microcomputer, which is oriented towards being built into scientific and measurement instruments as well as terminals for document processing.

The second model class is the SM51. The technical specifications of these models have been improved by 200 to 400 percent over the first stage models by means of changing over to a new component base and new design solutions.

The third class of models is the SM52; it is the best of the SM computers in terms of performance, memory size and possibilities. The SM50 and SM51 are used as the input-output channels in the SM52. Small problem-oriented networks in hierarchical systems are being built around the SM52.

The SM53 models are multiprocessor multimachine systems designed around models of other classes and assure an efficient distribution of the computing process over the system components by means of the operating system.

The SM54 models are special purpose processors that are hard-wired for particular algorithms (a fast Fourier transform, matrix operations, etc.), because of which they have a quite high speed (on the order of tens of millions of equivalent operations per second).

The evolutionary development of the hardware is represented in the second stage of the SM computers by the SM1410, SM1420, SM1210, SM1600, SM1300, etc.

It should be noted that the SM3 and SM4 type computers have changed the nature of an engineer's work when performing scientific research. The computer was previously considered to be something unshakeable, and the experiment was usually made to fit its capabilities. In this case, the scientist was forced to develop electronic circuits and software for interfacing the computer to the studied object as well as for the control of the object. When the task changed, everything had to be started over from the beginning, which slowed down the research being done to an extraordinary degree. Now though, the extensive products list of hardware and software for SM computers makes it

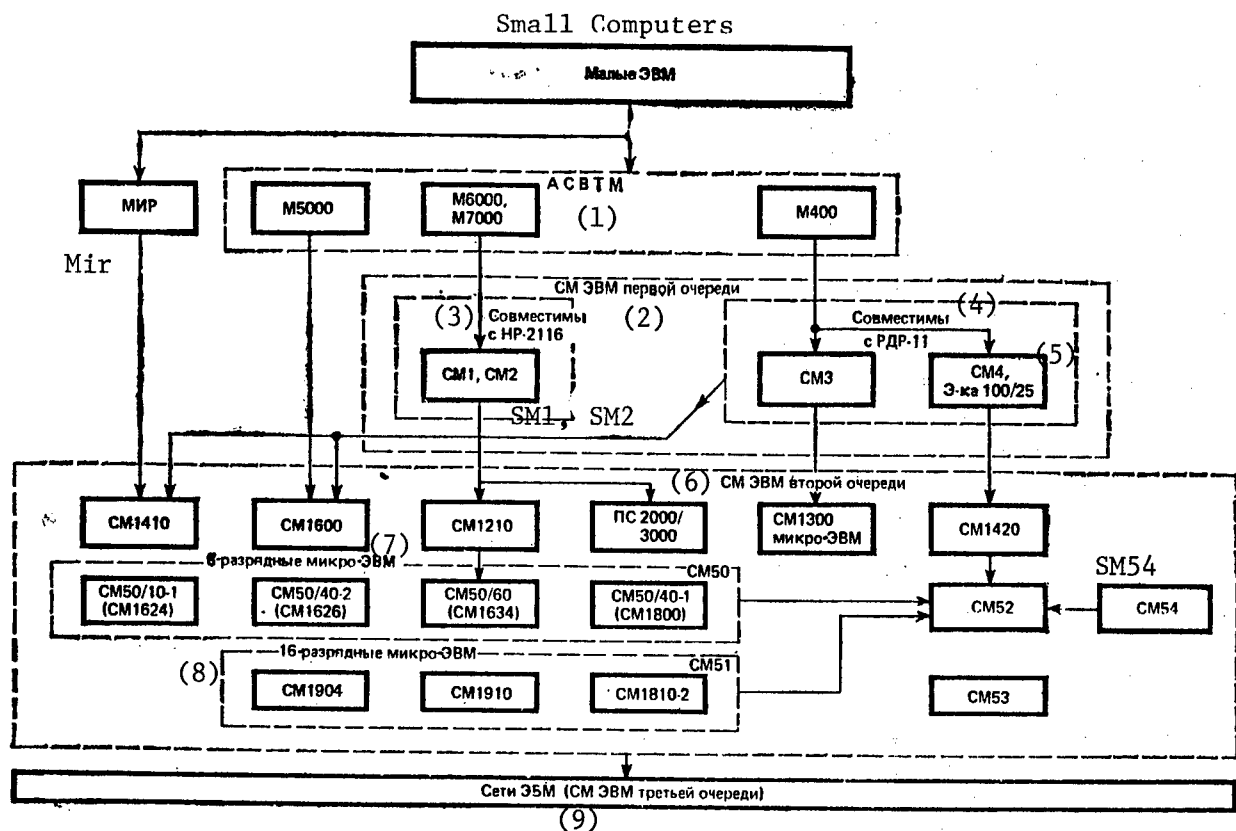


Figure 8. Diagram showing the development of small computers.

- Key:
- | | |
|---|--|
| 1. ASVTM [modular system of computer technology, modernized version]; | 6. Second stage of the SM computers; |
| 2. First stage SM EVM [system of small computers]; | 7. 8-bit microcomputers; |
| 3. Compatible with the HP-2116; | 8. 16-bit microcomputers; |
| 4. Compatible with the PDP-11 | 9. Computer networks (third stage of small computers). |
| 5. SM-4, Elektronika 100/25; | |

possible to use standard peripherals to assemble a special purpose computer system for the execution of a specific task, select the appropriate applied program package and conduct the experiment without once touching a soldering iron or getting involved in the writing of programs. In case the task changes, only the configuration of the computer system and the applied program package changes. Just this approach to the automation of experimentation enables the scientist today to sharply boost the speed, quality and cost effectiveness of scientific research without increasing the number of personnel on staff in scientific laboratories.

Despite the extensive products list of peripherals and the capabilities for real-time operation of YeS and SM computers in scientific experimentation

directly at the object of the research, it is impossible today to make do without microprocessor controllers and microcomputers, which the scientist must select himself from the available industrial models or design and fabricate using the manufactured microprocessor sets. In this case, it is important for the ASNI designer and user to understand that despite the similarity of a microprocessor in terms of its structure and major functions to a computer processor, its main purpose is to replace digital systems having a fixed structure, which were previously designed, and even today are still designed in many cases by an electronic engineer.

The microprocessor has become so inexpensive at the present time that it is appearing everywhere possible [11]. It is well known that the replacement of the large electric motors with drive shafts and belt drives in manufacturing operations in the 1920's and 1930's with small electric motors built into the machine tools and mechanisms was a revolutionary shift in machine building and made it possible to significantly improve machine tool design and manufacturing technology and also obtain a considerable economic impact. The effect at the present time is also being felt in just the same way in science and technology through the use of microcomputers or microcontrollers in scientific equipment, technology and production.

It is completely obvious that microprocessors will be widely used in the near future and is being used even today in computers, their peripherals, in scientific and technical apparatus as well as in auxiliary equipment. Thus, for example, only one or two of the 3,000 exhibited machine tools at the international "Euro-83" exhibition in France which was devoted to modern machine building did not have a built-in microprocessor controller or microcomputer.

In 1983, industry in our country was set the task of producing electronic and measurement equipment only with built-in microprocessor hardware in the 12th Five-Year Plan.

What is the component base for our domestic developmental efforts in the field of microprocessor engineering?

We shall discuss the development of Soviet microprocessors and their use in the YeS and SM computers as well as in microcomputers and controllers (Figure 9). All of the integrated circuit microprocessor sets that have been developed and are being produced can be divided into two groups: general purpose and special purpose. Microprocessor LSI circuits used in computer hardware and digital automation are called general purpose IC's. The following well-known IC microprocessors belong to this group: the KR580, K587, KR588, K589, KR1804, KR1810, etc. Microprocessor IC's intended for the construction of just one type of computer are called special-purpose. These include, in particular, the KR581, K536, K1801 and other sets. Moreover, microprocessors are broken down into fixed word length and bit-slice (with a configurable word length) devices. This is explained by the fact that when using bit-slice microprocessors, the designer gains the capability of modifying the computer devices and increasing their word length.

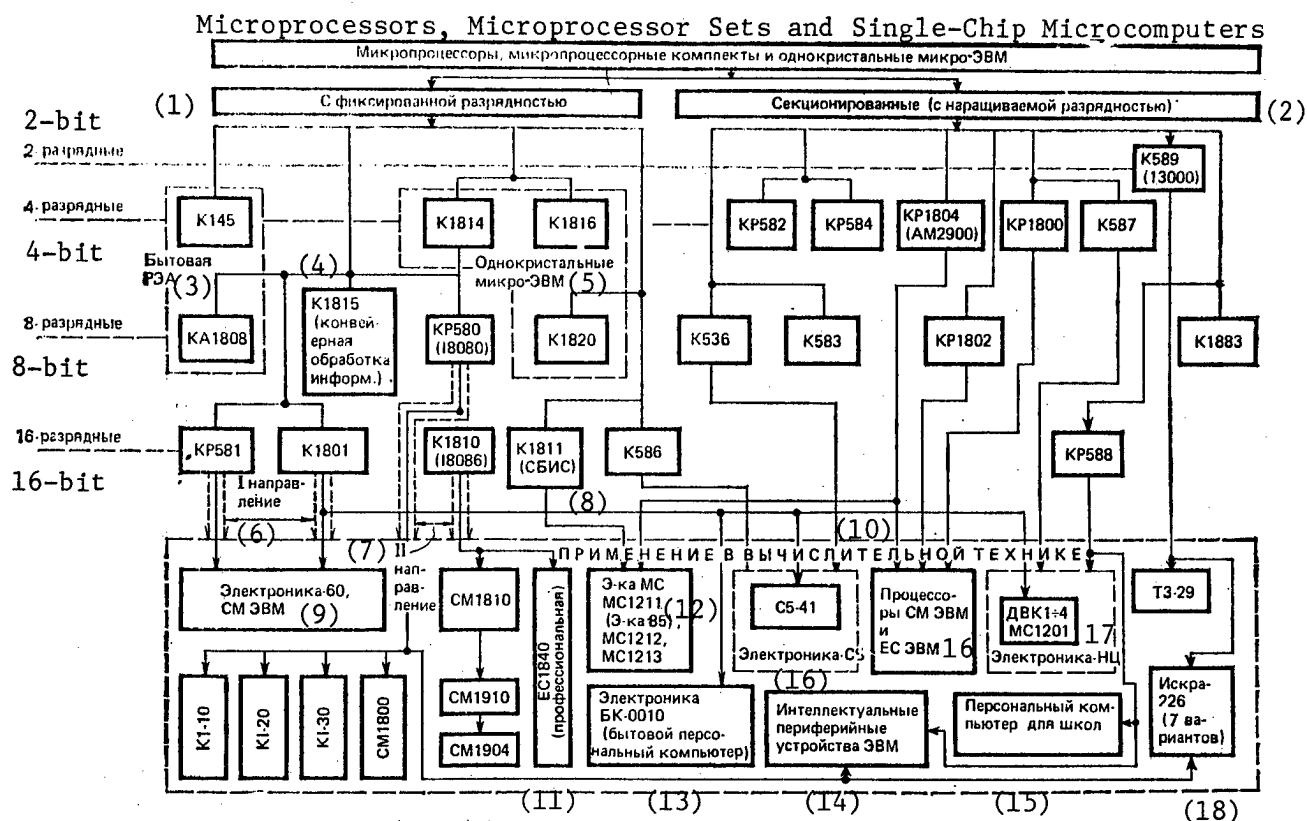


Figure 9. Diagram showing the development of microprocessors and their applications in computers.

- | | |
|---|--|
| Key: 1. With a fixed word length; | 11. YeS 1840 (professional); |
| 2. Bit-slice (with a configurable word length); | 12. Elektronika MS, MS1211, (Elektronika 85), MS1212, MS1213; |
| 3. Consumer electronic equipment; | 13. Elektronika BK-0010 (household personal computer); |
| 4. K1815 (pipeline data processing); | 14. Intelligent peripherals for computers; |
| 5. Single chip microcomputers; | 15. Personal computer for school; |
| 6. Direction I; | 16. SM and YeS computer processors; |
| 7. Direction II; | 17. DVK [interactive computer system] 1--4, MS1201; Elektronika-NTs; |
| 8. K1811 (VLSI); | 18. Iskra-226 (7 variants). |
| 9. Elektronika-60, SM computer; | |
| 10. Applications to computer hardware; | |

When microprocessors appeared, apprehensions arose among some specialists that the electronic engineering profession would die out and all engineers would be engaged only in the development of algorithms and programs for standard microcontrollers and microcomputers. In this regard, the design of digital systems using bit-slice microprocessors opens up new possibilities and prospects for the creative activity of an electronic engineer. However, it must not be forgotten that not only skill in the design of new electronic circuits around microprocessors is required in this case, but the engineer

must also have a good understanding of programming, while observing the requisite proportions between circuit (electronic) design and software solutions [12].

Despite the extensive products list and large number of microprocessor sets being manufactured, designers today are in no hurry to use them in new designs. And this is not just because of the lack of the necessary skill in this field. First of all, there are practically no specialized peripherals for microcomputers, the dimensions of which would conform to the dimensions of the microprocessor hardware (a single printed circuit board). The designer of a computer-aided scientific research system must as yet employ the YeS and SM computer peripherals for these purposes, which does not gain any advantage in manufacturing space. At the present time, measures are being undertaken to overcome these difficulties. Thus, for example, the production of miniature thermal alphanumeric printers has been set up and the production of compact "Winchester" external hard disk memories having a memory capacity on the order to 5 to 40 Mbytes has been planned; the dimensions of these "Winchesters" make it possible to house such an external memory in a single chassis with the microcomputer. We will remind the reader that previously only large computers had memories of this capacity.

Two trends can be noted at the present time in this area based on the microprocessors, microcomputers and their software treated above:

- Microcomputers and microcontrollers that are program compatible with the small type SM3 and SM4 computers (for example, the "Elektronika-60", "Elektronika NTs-80", DVK [interactive computer system], etc.) are to be used for direct communications with the object and the experimental data processing in a computer aided scientific research system;
- It is preferable for terminals, interfaces and in ASNI networks to use microcomputers designed around the KR580 (18080) and K1810 (18086) microprocessors which make it possible to use powerful software developed for these microprocessors (for example, the SM1800, SM1810 and other microcomputers). In case none of these microcomputers is suitable in terms of word length or speed, then nonstandard microcontrollers must be developed using KR1804 bit-slice microprocessors, which at the present time are the fastest and have the greatest functional capabilities.

When selecting a microcomputer, one must pay attention to its complement of peripherals, as well as the hardware and software compatibility with other computers. Experience with the operation of the "Elektronika-60" microcomputer is interesting in this regard; because of its program compatibility with the SM3 and SM4 minicomputers, it was acknowledged as the most popular computer in the 11th Five-Year Plan. Since this machine was supplied practically without peripherals (even without a display), its effectiveness was sharply degraded, which generated valid complaints by the users. This is why in the 12th Five-Year Plan the manufacturing plants will not count an individual computer as a product unit, but rather a computer system equipped with all of the peripherals needed for operation.

The validity of what has been said is confirmed by the SM1800 computer system that is being produced within the framework of the SM computers and which has won the most widespread recognition among users, since it is delivered to the customer completely equipped with the requisite hardware.

In order to make use of the existing rich software for the YeS computers, the production of a professional personal computer, the YeS1840, is planned in the 12th Five-Year Plan; this computer can be used directly at a work station to perform the requisite calculations, and when necessary, can be interfaced directly with large YeS computers.

The State System of Automation and Industrial Instruments (GSP). The State System of Automation and Industrial Instruments was created at the beginning of the 1960's in the USSR; this system makes it possible to move from the solution of special case monitor and control problems to the creation of plant technical management automation systems, plant management automation systems, computer-aided scientific research systems and CAD systems, which perform comprehensive automation tasks [13]. The general structure of the GSP system and the power engineering, data, metrological, structural design and operational compatibility principles for GSP hardware were worked out.

Three groups can be defined in the GSP: general industrial automated control system hardware, hardware for local automated control systems and specialized automated control systems and computer hardware. In terms of the kind of power used for the information medium, GSP system hardware is broken down into electrical, pneumatic and hydraulic instruments and directing action controllers (without using supplemental power). In terms of the kind of function performed, GSP system hardware is combined in the following groups: the measurement of physical quantities, signal conversion and data transmission via communications channels, data collection, storage and processing and control inputs to the controlled object.

Considerable attention in the GSP system is devoted to the development of instrumentation and computer hardware. The first step in this direction can be considered to be the creation of the comprehensive modular ASET-1 and ASET-2 electrical measurement equipment systems. The next step is the development of a modular system of computer hardware, the ASVT-M, which has incorporated the following control computers: the M400, M6000, M7000 and M4030, as well as the M40 and M60 centralized monitoring machines and their modifications within the framework of SM computers. And finally, the fourth generation of this hardware includes the complex of hardware for local data and control systems (KTS LIUS-2), which was developed on the basis of large-scale integrated circuits and KR580 microprocessors [14].

Interfaces: at the beginning of the 1970's, a new trend appeared in computer hardware; the origination and development of this trend were related to the construction of automation systems and complexes for various purposes, built around large computers and minicomputers. These systems employed subsystems that contained software controlled modular equipment based on machine and machine-independent interfaces.

Because of this, we shall consider the concept of an interface or an interface system that is used in modern computer-aided scientific research systems [15].

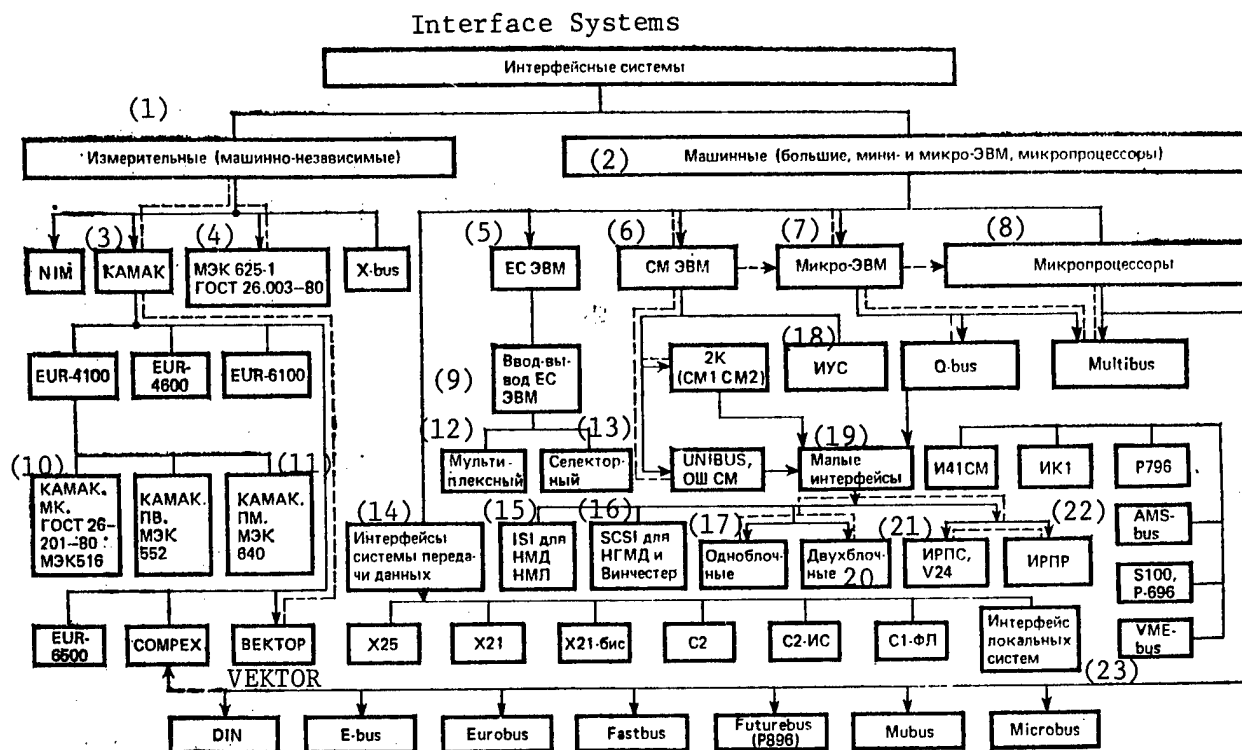


Figure 10. The classification of instrumentation and machine interface systems.

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|---|---|
| Key: 1. Instrumentation (machine-independent); | 13. Selective; |
| 2. Machine (large, mini- and micro-computers, microprocessors); | 14. Data transmission system interfaces; |
| 3. CAMAC; | 15. ISI for magnetic disk and tape storage; |
| 4. MEK [IEC] 625-1; GOST [State Standard] 26.003-80; | 16. SCSI for Winchester and floppy disks; |
| 5. YeS computers; | 17. Single module; |
| 6. SM computers; | 18. Information-control system; |
| 7. Microcomputers; | 19. Small interfaces; |
| 8. Microprocessors; | 20. Two-module; |
| 9. Input-output for YeS computers; | 21. IRPS, V24; |
| 10. CAMAC. IEC. GOST 26-201-80; IEC 516; | 22. IRPR; |
| 11. CAMAC. PM. IEC 640; | 23. Interface for local systems. |
| 12. Multiplex; | |

An interface system is defined as an aggregate of logic devices, joined together by a standardized set of linkages and intended for supporting data, electrical and structural compatibility, as well as for the execution of the algorithms for the interaction of the functional modules of a system in accordance with the established norms and rules.

Specialists working with complex ASNI's [computer-aided scientific research systems], information and instrumentation systems (IIS) and data-controlled systems (IUS) usually strive to employ a standard interface or a limited series of interfaces, however, it is difficult to resolve this problem in practice. On one hand, this is related to the desire of the specialists to bring the structure of the ASNI itself as close as possible to the specific engineering tasks, and on the other, to the poor preparation and lack of information of the specialists in the relevant fields. Moreover, ASNI theory is still inadequately developed and the capabilities of circuit design and microelectronics are far from exhausted; for this reason, the appearance of new interfaces is tied to the search for optimal structures, new and original operating modes as well as new wiring and structural designs.

Figure 10 shows the classification of the best known instrumentation and machine (for computers) interfaces [1, 16].

The most diverse computers are widely used in ASNI systems. In this case, an ASNI can be designed for the interfacing of any computer and the characteristics of a particular machine are not considered in the selection of the interface structure. In case another computer is used, only the interface circuit (adapter) is changed. A particular adapter must be developed for a given ASNI interface and each type of computer. Such interfaces are called machine-independent.

The scientific hardware and instruments incorporated in the systems along with the computer in an ASNI are input-output peripherals (UVV) and can be interfaced to the computer just as the computer I/O peripherals themselves are. While ASNI's are designed around quite definite computers, the computer I/O interface is adopted as the ASNI interface. Then the instruments and hardware of the ASNI must be designed with interface circuits that satisfy the requirements of the computer interface (the machine interface).

The CAMAC (VEKTOR) and MEK [IEC] 625-1 are to be recommended at the present time for ASNI applications from among the interfaces shown in Figure 10. In the case when computers are used in the ASNI, computer systems with UNIBUS (common bus), Q-BUS and MULTIBUS interfaces are preferred. A further development of the CAMAC system based on microprocessors is to be included among the promising interfaces: the COMPEX, as well as the DIN and FUTUREBUS interfaces.

Computer-Aided Scientific Research System Software

Important parameters of scientific research automation systems under development are the diversity, efficiency and reliability of the software incorporated in them. Real-time computer systems are becoming increasingly widespread in the design of automated control systems in industry or in scientific research. These systems are tied directly into the research object, because of which, the information is fed from the point it is generated to the main memory, avoiding intermediate storage. Based on the collected data, control inputs are generated and they are transmitted to the object so rapidly that they do not have time to lose their optimal properties. The software for such systems must meet specific requirements, which entails an increase in the software engineering costs.

A characteristic feature of automation systems for experimental research is their uniqueness. This necessitates the development of a significant portion of the software when creating each new system. Moreover, for example, as compared to automated control systems for manufacturing processes, the software for computer-aided scientific research systems must as a rule be more flexible and diversified. This is related to the fact that when performing experimental research, the selection of the method used to attain the result is usually set as one of the goals. During the course of the research, in step with the accumulation and processing of the data from the experiments, the research goal or even the object of the research may change. Since it is impossible to provide for all possible research goals and methods of attaining them beforehand, the software of such systems includes programs whose utilization is the most probable, and provisions must also be made here for aids that facilitate the development and incorporation of new applied programs in the software.

The specific ASNI features noted here lead to the fact that significant efforts must be devoted in the design of such systems to the development of special software. One of the most important conditions for the success of such design efforts is the proper organization of the process of preparing the program systems.

The selection of the optimal conditions for the execution of the experiments and the processing of their data number among the most important functions of experimental research automation systems. The corresponding programs must be incorporated in the standard part of the special software of these systems.

One can discriminate the stages of simulating and planning the experiment as well as the implementation of the resulting designs and data processing in the experimental research process. In this case, in step with the accumulation of observational data, the representation of the object is made more precise, new hypotheses are put forward concerning the mechanism governing the phenomena in it and models are constructed that conform to the specified research goals. It became with the appearance of ASNI's to formulate and execute complex scientific research tasks on a broad scale, where these tasks are related to the selection of the best model of an object from a set of several models, as well as to the construction of models describing the behavior of the object in a wide range of variation of the governing factors, etc.

The systems of programs and individual applied programs that are developed perform their functions in interaction with the computer operating systems. The efficiency of the application of these programs can be assured only with the most complete possible utilization of the operating system capabilities. For this reason, designers of applied programs should have a sufficiently complete understanding of such systems.

Figure 11 shows the classification of operating systems for the YeS computers, SM computers and microcomputers. While in order to operate the YeS computers, it is sufficient for the user to learn just the YeS operating system, which functions practically with all the computers (starting with the YeS1020 and

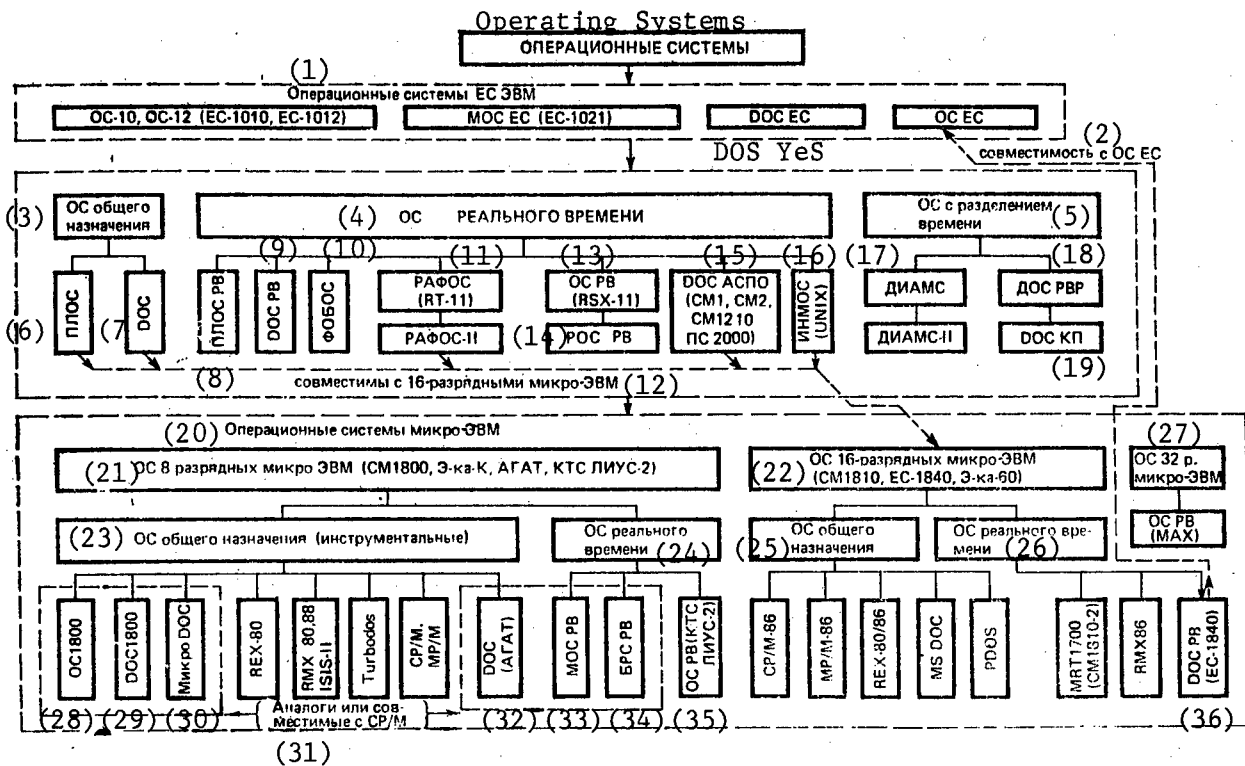


Figure 11. The classification of operating systems.

- Key:
- | | |
|---|--|
| 1. Operating systems of the YeS computers; | 21. Operating systems for 8-bit microcomputers (SM1800, Elektronika-K, AGAT, KTS LIUS-2 [local area data-control system]); |
| 2. Compatibility with the YeS operating system; | 22. Operating systems for 16-bit microcomputers (SM1810, YeS-1840, Elektronika-60); |
| 3. General purpose operating systems; | 23. General purpose (utility) operating systems; |
| 4. Real-time operating systems; | 24. Real-time operating systems; |
| 5. Time-sharing operating systems; | 25. General purpose operating systems; |
| 6. PLOS; | 26. Real-time operating systems; |
| 7. DOS; | 27. 32-bit microcomputer operating systems; |
| 8. Real-time PLOS; | 28. OS 1800; |
| 9. Real-time DOS; | 29. DOS 1800; |
| 10. FOBOS; | 30. MicroDOS; |
| 11. RAFOS (RT-11); | 31. Similar to or compatible with the CP/M; |
| 12. Compatible with 16-bit microcomputers; | 32. DOS (AGAT); |
| 13. Real-time operating system (RSX-11); | 33. Real-time MOS; |
| 14. Real-time ROS; | 34. Real-time BRS; |
| 15. ASPO DOS (SM1, SM2, SM1210, PS2000); | 35. Real-time operating system (KTS LIUS-2); |
| 16. INMOS (UNIX); | 36. Real-time disk operating system (YeS-1840). |
| 17. DIAMS; | |
| 18. Time-sharing DOS; | |
| 19. Collective-use DOS; | |
| 20. Microcomputer operating systems; | |

ending with the YeS1060), in the case of the SM computers, a designer of an ASNI system is offered an extensive set of general purpose, real-time and time-sharing operating systems. The RAFOS (RT-11) and OS RV [real-time operating system] (RSX-11) systems have become the most popular for the SM3 and SM4 computers in ASNI systems at the present time.

There is CP/M, ADA, UNIX, Basic, APL . . . so many names! Some of them are well known to the readers and others are completely new. However, this already rather long list of different software systems for microprocessors and microcomputers is changing every month because of the appearance of new products. The development of computer hardware, the design of efficient operating systems and the appearance of displays have provided researchers with the capability of directly controlling the course of task execution interactively on a computer. This makes it possible to combine formalized and heuristic research methods in the best possible manner as well as provide the experimenters with on-line information about such methods. When using interactive programs, it is not necessary to initially have all of the data available needed for the execution of the task. The lacking information can be fed in during the running of the experiment and it frequently depends on the intermediate results of processing the data fed in earlier. This information is usually certain solutions adopted by the researchers on the basis of their experience and intuition; moreover, they can also change the data fed in earlier if the data does not conform to the results obtained.

The interaction between an investigator and a computer is set up in the form of questions and answers. Three interaction variants exist. In the first instance, the interaction is controlled by the computer which poses the questions and their sequence is a function of the user responses. This operating mode is frequently used by "consultant computers"; they render assistance in the formulation of the task and the selection of the method of task execution. However, the mode of interaction management by the investigator is employed more frequently. In this instance, the questions posed by the person to the computer contain instructions needed for the selection of the algorithm for the corresponding data processing program. The computer's answer is the results of the program calculations. And finally, the third case combines the first two and allows for the formulation of questions both by the researcher and the computer. An example of the organization of an interactive applied program package system is depicted in Figure 12. The applied program package includes the library of programs, the information system and the control program. The researcher interacts with the computer through an alphanumeric display, which includes a keyboard, light pen and a "mouse" cursor control peripheral. The computer's questions and answers are displayed on the screen, while the researcher's questions and answers are fed into the computer through the keyboard and the display screen with the light pen.

The control program is tied into the information system via the operating system of the computer. The information system incorporates the common and individual archives for the users, by means of which information is transmitted when changing over from the execution of one job to another. The program libraries include sets of modules and ready-made programs encompassing

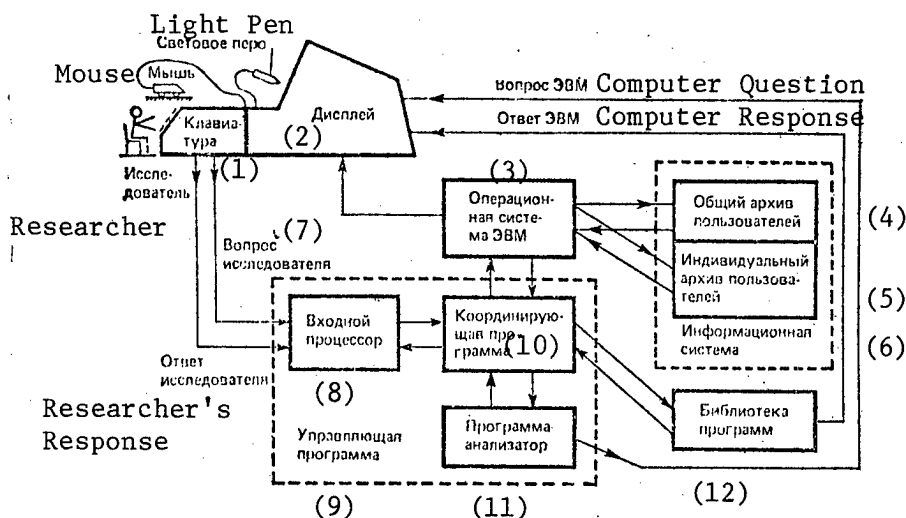


Figure 12. Block diagram of an interactive package of applied programs for a computer-aided scientific research system.

- Key:
- | | |
|----------------------------------|---------------------------|
| 1. Keyboard; | 7. Researcher's question; |
| 2. Display; | 8. Front-end processor; |
| 3. Computer operating system; | 9. Control program; |
| 4. Common archive for the users; | 10. Coordinating program; |
| 5. Individual user archive; | 11. Analyzer program; |
| 6. Information system; | 12. Library of programs. |

the subject area of the research, as well as the most frequently used working programs. The control program consists of a front-end processor that coordinates the programs and analyzer programs; this processor is necessary for organizing the interaction of the computer with the researcher.

Funds of Algorithms and Programs

Considerable savings are achieved in the developmental costs of computer system software through the use of ready-made program modules and sets of programs. In this regard, considerable attention is being devoted in our country to the design of efficient aids for exchanging information on software development as well as exchanging the programs themselves. The USSR State Fund of Algorithms and Programs (GFAP) was organized for this purpose in 1966.

Not only algorithms and programs are accepted for the registration in the GFAP, but also procedural information materials associated with the development of software.

Unified rules for the formatting of algorithms and programs forwarded for registration have been worked out. The observance of these rules makes it possible to disseminate the algorithms for their implementation in a broad group of interested organizations.

The developed programs and algorithms are included in the enterprise fund, and after that, also in the sectoral fund in case they have topical importance. The incoming materials are monitored and they are checked in the sectoral funds; a decision is made concerning their incorporation in the GFAP. The materials are then forwarded to the All-Union Scientific and Technical Information Center (VNTITsentr). The published materials are forwarded to the USSR State Public Scientific and Technical Library (GPNTB). Information on the materials included in the GFAP, arriving from the VNTITsentr and USSR GPNTB is stored in the Computer Center of the USSR Academy of Sciences. The functions of the Computer Center of the USSR Academy of Sciences also include the development of procedural materials for the expansion of the GFAP, the management of the fund directory as well as the publication of collections of information and procedural materials on computer software.

Information Retrieval, Processing, Transmission and Storage in Computer-Aided Scientific Research Systems

The information society, the noiseless revolution and the paperless office - these and popular terms similar to them designate the revolution taking place at the present time in the life of society; the development of information technology based on the electronic tools for information collection, processing, storage, transmission and dissemination has become a reason for this. This revolution is having a profound effect on the generation of scientific knowledge and communications as well as the activity of scientists and design organizations within the framework of ASNI applications to scientific research.

The bulk of the information used in research and development is generated directly by science itself. Until recently, the increasing avalanche of scientific and engineering information was perceived by many as a destructive phenomenon, frequently called the information explosion.

The appearance of automated information systems (which include or are connected via communications channels to computer-aided scientific research systems), designed around automated databases, computer networks and intelligent terminals is a fundamental solution to the information problems of science and engineering.

Because of the sharp increase in the volume of information that can be stored in a computer memory, it has become possible to develop on-line accessible databases having a capacity of several billion words, which, for example, can contain all of the reference information for a period of several years and can support the retrieval and output of information at a terminal only one to two seconds after the query input. While the epoch of database exchange via magnetic tape was opened up in the 1970's, a new era of communications is beginning in the 1980's: the industrial application of data transmission networks for information support of scientists and engineers. The Western European EURONET network was brought on line in 1980. The creation of information-computer networks has been started in the CEMA member nations; scientific information service tasks occupy a central position in the tasks of these networks.

The majority of large scientific centers both here in the USSR and abroad are equipped with high performance computer centers. However, the necessity of exchanging information, planning and performing compatible experiments requires the integration of the computers into computer networks. The Akademset [academy of sciences network] is being created for these purposes in the USSR; many scientific centers in the U.S. and Western Europe have outputs to such networks as ARPANET, EURONET and TYMNET.

The first stage of an information network for data teleprocessing [17] was placed in trial operation in 1980 by the International Center for Scientific and Technical Information (USSR). The following can be cited among the data-bases of the greatest interest to specialists: INIS (nuclear science and engineering); INSPEK (physics, electronics, computers and control); NTOE (scientific and technical reports on power engineering); CPI (multiple topic index of conference materials); SCl (multiple topic index of scientific references). The operational experience of Moscow scientists with such systems shows that young scientists most readily turn to the interactive retrieval of scientific and technical information. The main advantage of the interactive retrieval of scientific and technical information, as evaluated by the users, is the capability of rapidly obtaining an answer to a question (in 15 minutes on the average). It turns out that with the interactive retrieval of scientific and technical information, it is sufficient to read up to 60 percent of the information from the display screen without printing it out; only 10 percent of the information found was previously unknown to the users. All users note the substantial advantages of the interactive retrieval of information as compared to all of the methods previously known to them.

Examples of Computer-Aided Scientific Research System Designs Based on Instrumentation Computer and Problem-Oriented Systems

It is most expedient to use minicomputers and microcomputers when performing modern scientific research and comprehensive tests on new equipment by means of computer-aided scientific research systems; such computers can be interfaced to large computers as terminals when it is necessary to increase the computer system performance.

The extensive capabilities of the SM series of minicomputers has made it possible to use them as the basis for a number of standard instrumentation computer (IVK) and control problem-oriented (POK) systems oriented towards scientific research automation. Depending on the hardware used, these systems can be divided into two groups (Figure 13):

- The IVK-1 - IVK-4 and IVK-20, built around the SM computers and the CAMAC system, intended for the automation of general physics (IVK-1, IVK-2 and IVK-20), optics (IVK-3) and laboratory scientific (IVK-4) research;
- The IVK-7 and IVK-8, designed around the SM computers and ASET measurement equipment; these computer systems support the collection, processing and storage of data during computer-aided scientific research in various fields of science and engineering.

Another area in the development of standard IVK's [instrumentation computer complexes] is the creation of such systems for computer-aided engineering,

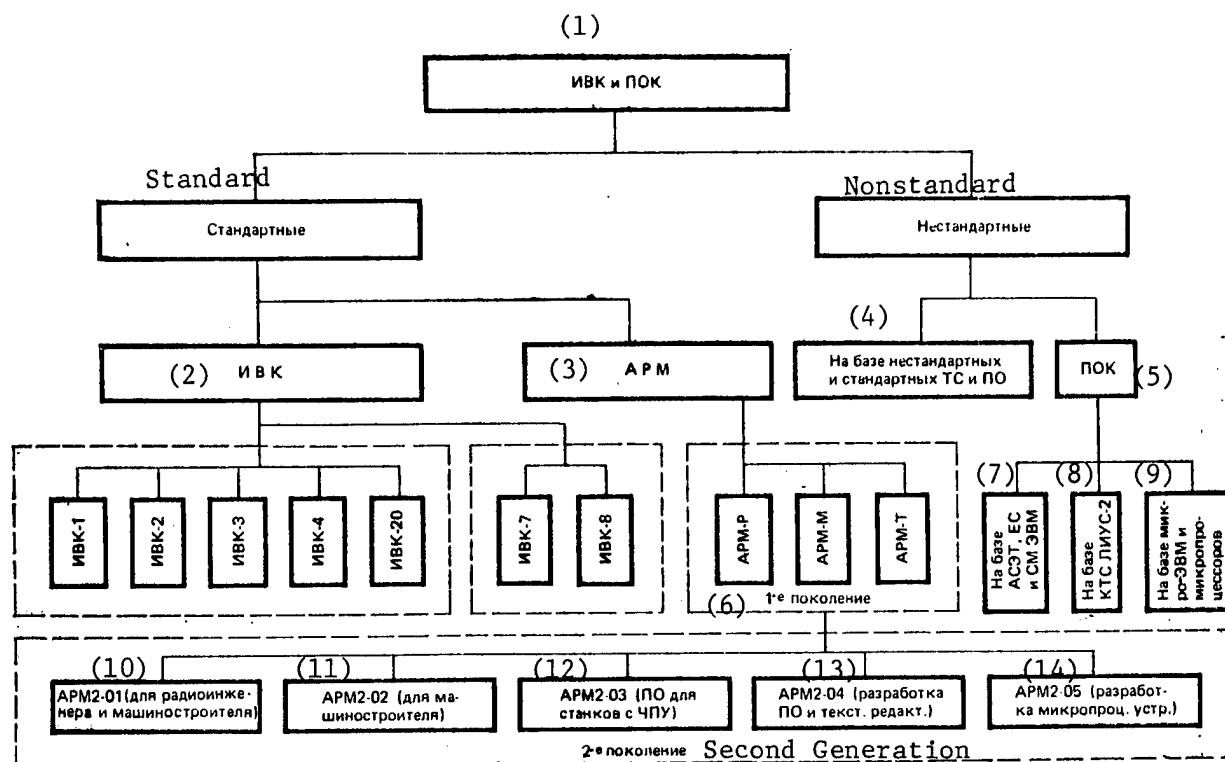


Figure 13. Standard and nonstandard instrumentation computer and problem-oriented systems for computer-aided scientific research systems.

- Key:
- | | |
|--|---|
| 1. Instrumentation computer and problem-oriented systems; | 9. Based on microcomputers and microprocessors; |
| 2. Instrumentation computer systems; | 10. ARM2-01 ([CAD station] for a radio engineer and machine tool designer); |
| 3. Automated work stations; | 11. ARM2-02 (for a machine-tool designer); |
| 4. Based on nonstandard and standard hardware and software; | 12. ARM2-03 (software for numerical control machine tools); |
| 5. Problem-oriented systems; | 13. ARM2-04 (software engineering and word processing); |
| 6. First generation; | 14. ARM2-05 (design of microprocessor hardware). |
| 7. Based on the ASET, YeS and SM computers; | |
| 8. Based on the KTS LIUS-2 [complex of hardware for local area information and control systems]; | |

computer-aided design, programming, etc.; these include (Figure 14):

- Computer-aided work stations for a radio engineer (ARM-R), a machine-builder (ARM-M) and a process engineer (ARM-T);
- Computer-aided work stations for information personnel (ARM Referat), microprocessor design engineer (ARM 2-05) and for a programmer (ARM Programmist).

The extensive products list of microelectronic computer hardware being produced by industry additionally offers the scientist considerable

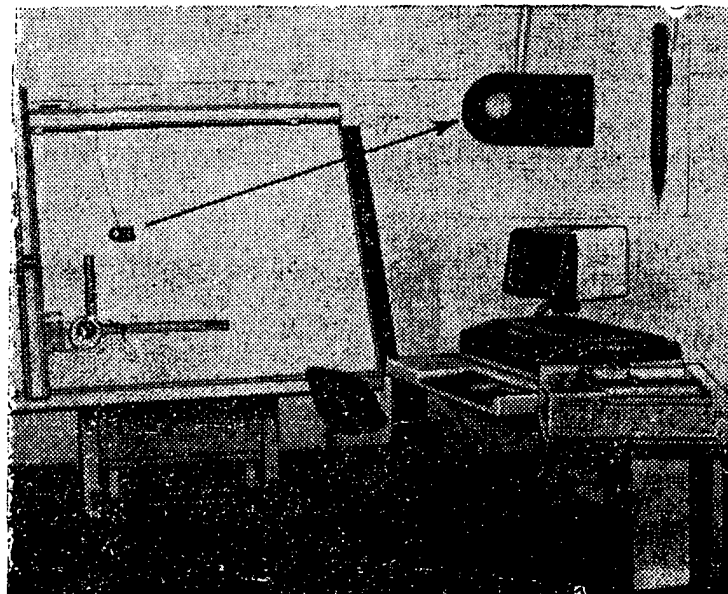


Figure 14. Computer-aided work station for an engineer.

possibilities in the design of specialized (nonstandard) computer-aided scientific research systems. In this instance, the user can design research systems around both standard and nonstandard instruments and hardware, based on one's own designs employing the latest achievements in the field of microelectronics.

Another trend is the construction of problem-oriented systems based on the standard hardware and software for the YeS and SM computers, the ASET [modular system of electrical instrumentation hardware], CAMAC, KTS LIUS-2 as well as microcomputers and microprocessors. The role of the designers in such computer-aided scientific research systems reduces to the writing of the algorithms and the software.

We shall consider the major parameters and functions of instrumentation computer systems for scientific research.

The IVK-1 and IVK-2 systems are the hardware and software base for the construction of computer-aided scientific research systems for general physics.

The basic complement of the IVK-1 includes the SM-3P 16-bit processor, a 28 Kbyte RAM, a punched tape terminal, an IZOT 1370 magnetic disk peripheral memory, a VT-340 display and a DZM-180 alphanumeric printer.

The basic complement of the IVK-2 is distinguished by a more powerful processor, the SM-4P, a RAM increased to 64 Kbytes and up to 4.8 Mbytes of peripheral magnetic disk storage, an IZOT 5003 peripheral magnetic tape store and an SM 6315 miniature alphanumeric printer.

Two crates each are used as the CAMAC hardware in the IVK-1 and IVK-2; each of these crates includes the following functional modules: an analog to digital

converter, switcher, registers, digital to analog converter, counter, pulse generator and teletype interface module.

The IVK-1 is constructed in the form of two standard SM computer racks, while the IVK-2 is in the form of three such standard racks, with two CAMAC crates built into one of the racks and a separate operator's terminal and printer.

The IVK-3 system is problem-oriented towards the automation of experiments that are performed with optical spectral instruments in various fields of science. The IVK-3 complement is the same as that of the IVK-1, with the addition of a plotter and a digital voltmeter. The CAMAC hardware employs a crate that includes the following set of functional modules: two A/D converters, a switcher, two dual-channel D/A converters, two modules for the control of a stepper motor, two pulse counters, registers, a timer, and a digital voltmeter control module.

Instrumentation computer systems are being produced by Soviet industry in which the measurement and conversion hardware, which ties the experimental equipment to the computer, is designed to the standards of the modular system of electrical measurement hardware (ASET).

The USSR Academy of Sciences Institute of Radioengineering and Electronics in conjunction with the Institute of Electronic Control Machines and the Institute of Electronics and Computer Technology of the Latvian SSR Academy of Sciences has developed the structure for a multimachine information computer system that can be used as a standard type in the design of a computer-aided experimental research system. Microprocessors that support greater monitor, control and processing capabilities for the experimental data at the crate level are beginning to be used at the present time as the frame controllers of the CAMAC system which is widely used in computer-aided scientific research systems.

We shall now consider some specific examples that demonstrate the expediency of the automation and design of scientific investigations. We shall turn to the field of science whose successes are near and dear to all of us - to medicine. Let it be necessary to use an experiment on animals to evaluate the efficacy of the comprehensive effect of several pharmaceuticals. The dependent variable is the percentage of individuals that get well. It is obvious that the effect of treatment will be governed not just by the doses of the medicines and the time of their administration, but also by the procedure for the use of the preparations. You might try to estimate the impact of each of them, the procedure for the administration and the interaction in a traditional single factor experiment. This would be lengthy, expensive and not very effective. The design of the experiment makes it possible to solve this problem by means of a small number trials. Thus, for example, a plan consisting of eight trials in all was used to study the efficacy of two antiviral preparations in experiments with chick embryos. The investigation made it possible to develop recommendations for the selection of the optimal scheme for the use of the preparations, taking into account the procedure for their administration and to achieve 100 percent survival of the embryos.

Yet another widespread problem in medicine for which the methods of experimentation planning are effective is the evaluation of the aftereffects of medications when selecting the optimal strategy for treating patients.

The "Teaching Program System in Cardiography" for predicting the postoperative status of the cardiovascular system of a patient when prosthetic heart valves are used was shown at the "Nauka-83" ["Science-83"] international exhibition in the Soviet section. The basis for the design and operation of the system is as follows:

- A modular structure that permits program segmentation;
- The representation of the processes being studied in the form of mathematical models;
- The decomposition of complex models into simpler ones, as well as the generation of a complex process model by means of compensating for the elements of the model;
- The adaptation of the model to a patient with optimal control and execution of the tasks of parametric identification using statistical data;
- Learning based on the accumulated experience and the associative reproduction of the experience;
- Control of the course of the computing process for the purpose of reducing expenditures of machine time and memory.

The system takes the form of an aggregate of interconnected program blocks, in one of which the functional model of the cardiovascular system is generated on the basis of differential equations. Taking into account the experience with previous solutions and the statistical data, the model parameters are set up for the characteristics of the particular patient. The change in the cardiovascular system status of the patient is predicted for the case when prosthetic heart valves are used. In this case, information on the artificial valves is also considered as well as the results of similar surgical procedures.

The reliability of the prediction depends greatly on the amount the system has learned, which is determined by the number of tasks executed earlier as well as the volume and quality of the statistical information.

The program complex can also be used for predicting the results of using various medications on patients and for solving an extensive class of problems of a medical, biological, economic and technical nature.

The system works with a FORTRAN type language and the software is implemented using the YeS series of computers and a multiprocessor PS-2000 computer system. Segmentation is provided when there is a random-access memory of no less than 30 K and peripheral memories are present. The information is fed out to a display, an alphanumeric printer and a plotter. The operation of the learning program complex has demonstrated its high level of effectiveness:

- The task execution time is reduced by a factor of 20 to 40 times when a YeS1045 computer is used;

--When a PS-2000 is used, the task execution time is reduced by a factor of 1,000 to 2,000 times, including a reduction of 30 to 40 times by means of execution in parallel.

Along with the prediction of illnesses, computer-aided scientific research systems also permit us to look into the past development of living organisms. The beginning of such research was a computer experiment to study the evolution of the population of the Copepoda subclass of cyclopoids subject to changing environmental conditions. The model constructed for the population was the first to take into account in the practice of "computer" evolutionary studies both the genetics and ecological parameters. The numerical simulation showed that as early as after 200 to 700 generations, individuals came to be "born" that were adapted to the new conditions much better than the original population. This new population differed significantly from the maternal one in many attributes, and the main thing was that the new population could not cross with the old, i.e. reproductive isolation was in force - one of the conditions for the formation of a species. Thus, as a result of the "evolution" in the computer-aided scientific research system, a new species "appeared". Another experiment called "From Worms to Crabs" simulated the evolution of arthropods. The basis for this experiment was three principles:

- Equal probability of progressive and regressive changes in the species;
- Gradual evolution, i.e. the absence of sharp changes;
- A limited "biosphere", capable of "feeding" only 100 species. For this reason, the unsuccessful species least adapted to a given environment were erased from the computer memory ("died out") and species with the best adaptation took their place ("multiplied"). The estimate of the adaptedness was an integral estimate - in an entire aggregate of 24 vitally necessary attributes. For example, if ambulatory extremities appeared, the use of which interfered with the extraordinarily heavy shell, the "value" of this attribute was taken as 0. The "evolution" in the computer-aided scientific research system at first went extraordinarily slowly: none of the newly occurring species was strengthened with a rigid outer skeleton, which constitutes the characteristic feature of arthropods. And only when constraints on the food resources and the possibilities of predatory feeding related to this were introduced into the program did the pace of evolution accelerate significantly. The hard skeleton arose rather quickly and the skeletal types were in complete conformity with those observed in nature. The animals went out on dry land twice in the computer simulation: at first on three pairs of legs, just as insects do, and then on four, just as the arachnidae do.

The fast and simultaneous origination of the hard skeleton proved to be the most interesting thing in these experiments. Up until now, the independent appearance of skeletons among the most diverse organisms approximately 60 million years ago was an enigma for paleontologists: corals, arthropods, etc. The computer experiment made it possible to hypothesize that the change in the conditions of existence of the living organisms in this geological epoch brought about the discovery of the predatory manner of feeding and the appearance of predators. And the predators then "automatically" gained the evolutionary value of a strong skeleton providing reliable protection against attack.

A second program that simulated the evolution of chordata, to which man also belongs, was no less successful. Having started with the first ancestral organism, a so-called proto-lancelet [branchiostoma or amphioxus], the entire diverse set of living beings known from paleontology was obtained in the computer: from fossil fishes and lizards to birds and mammals (including those that were similar to australopithecanthropoids that actually existed). In contrast to the previous experiments, the environment conditions were assumed to be constant. Evolution occurred nonetheless: interaction between the organisms proved to be completely sufficient for it. It must be noted that no stringent constraints were placed on the "external appearance" of the cybernetic beasts in the model. Large terrestrial vertebrates with three pairs of extremities - "centaurs" and ball-shaped beings capable of only rolling along the surface were quite capable of "developing" from the original proto-lancelet. However, the appearance of such exotic "animals" was not noted in any of the computer experiments. In one of the computer trials, the evolution of the chordates was subjected to severe tests. A form of fish with only one pair of pectoral fins appeared and became successfully adapted to fresh water. This led to the fact that an accidental "invalid" having only one pair of extremities - a thoracic pair - subsequently came out on dry land. As a result of this, evolution was held up for 400 million years (machine evolution time) and only then when the terrestrial "beast" was outfitted with a second, pelvic pair of extremities did the evolution continue its course.

The broad scope of scientific research in medicine necessitated the development of a computer-aided scientific research system at the USSR Academy of Medical Sciences, which must accelerate the execution of scientific and technical tasks in the institutions and organizations of the Academy of Sciences. A specific program was worked out in the initial stage; the goals, tasks and hardware base for the ASNI were defined. The decomposition of the ASNI into subsystems and their subsequent analysis made it possible to draw the following conclusions:

- Object subsystems, the composition of which has been defined and precisely specified by means of a questionnaire survey, can be combined in several classes in accordance with the methods of data collection and processing;
- Service subsystems are combined in a compact unit with a relatively independent group of problems.

The latter conclusion has enabled the discrimination of the collective-use computer system (VSKP) as an organizational, hardware and software environment for the automation of scientific research. The division of the goals of a computer-aided scientific research system into major (external) and internal goals was ascertained and formalized at the same time.

Considering the fact that the creation of a collective-use computer system and a computer-aided scientific research system based on it is a strategic problem taking many years, particular attention was devoted in the development of the plan for the implementation of the computer-aided scientific research system to the multistage nature of bringing it on line. Thus, a high degree of economy is achieved, which is assured by small capital investments, low operational costs and the gradual placement of the collective-use computer

center and computer-aided scientific research system in service, starting with the most effective and best prepared tasks.

The PS-2000 Computer Systems

The parallel system 2000 (PS-2000) computer systems are intended for processing large volumes of data, predominantly in real-time. Maximum efficiency is achieved through the use of parallel algorithms. The applications areas of the PS-2000 are: geophysics, aerospace tasks, meteorology, agriculture, cartography, oceanography, medicine and biology, scientific computations, design, control, etc.

Scientific research in the field can be automated by means of a computer-aided scientific research system developed jointly by Soviet (USSR Academy of Sciences Institute of Radioengineering and Electronics) and French scientists and designed around a distributed CAMAC system using microprocessors. The system is intended for automating data collection and processing in field experiments performed in such areas as space research, environmental protection, prospecting for useful minerals, the study of thunderstorm sources, etc., which require the recording and processing of large data flows.

The system is based on a microcomputer with a RAM capacity of 128 Kbytes, compatible with the SM computers and designed in the form of CAMAC modules conforming to the EUR 6500 standard, and also employs an analog tape recorder and digital magnetic tape storage. The system can record data in analog and digital form, input and process the data in a computer, as well as display the processing results in digital and graphical form. Thus, the computer capacity of two SM-4 computers is achieved in a CAMAC crate under field conditions.

It should be noted that American scientists performed scientific research on board the Space Shuttle by means of a computer-aided scientific research system with a similar design based on two CAMAC crates. The designers only had to provide for standard shock absorbers for the scientific hardware at the mounting points. In this case, the entire effort involved in the development of the computer-aided scientific research system took no more than three months.

A Chemical and Biological Experimentation Automation System

The system is designed around the "Iskra-226" problem-oriented microcomputer and is an automated work station for a researcher which supports the control of the experiment, the documentation of the scientific data and its representation in a convenient form. The system is intended for the solution of a variety of physical, chemical, medical and biological problems as well as for problems of environmental protection, etc.

The system incorporates a number of unique experimental systems and instruments.

1. A general purpose reference standard porosimeter which can generate extensive and reliable information on the structure and physical-chemical properties of porous bodies. This porosimeter has the following advantages over those now known:

- It is applicable to samples of any chemical nature and any strength;
- It precludes errors in the measurements that are related to the deformation of the sample structure;
- It has the capability of studying structural changes in the same sample during the course of various physical, chemical and manufacturing processes;
- It has the capability of studying structural and structural-strength properties of easily compressible and powder samples.

The reference standard porosimeter is irreplaceable when investigating the porous structure of bodies of any chemical nature: starting with catalysts, structural materials and electrodes, and ending with polymers, medicines, etc.

2. A three-component electrochemical borehole system for studying and measuring geoseismic fields. The system is based on concentration-type electrochemical transducers for mechanical inputs having a high sensitivity to long period mechanical oscillations. The instrument provides for the three-component recording of an earthquake, has a simple and reliable structural design, makes it possible to record seismic oscillations in any spatial orientation without resetting and allows for data output via a geoseismic data processing line.

3. A water quality analyzer is intended for making analyses of the content of organic impurities in natural, drinking and waste water. The advantages of the instrument include fast analysis, differentiation of the organic impurities in terms of their oxidation susceptibility and an extraordinarily broad range of concentrations that can be recorded.

4. A complex of equipment for analyzing the molecular oxygen content in fluid and gaseous media, as well as for solving a number of specific medical and biological problems as well as for environmental protection applications. The utilization of the adsorption kinetics measurement of the oxygen content favorably distinguishes this instrument from the well-known devices based on polarographic analysis. This makes it possible to obtain a short measurement time, high sensitivity and precision as well as reduce the oxygen consumption during the course of the analysis and reduce the influence of intermixing of the medium to a minimum.

5. A system for the measurement of the impedance of electrochemical systems at infrared AC frequencies enables the measurement of the output impedance of certain electrochemical information transducers, as well as the study of the structure of the double electrical layer in low conductivity solutions.

The computer-aided systems treated here are already capable today of solving ecological problems related, for example, to air contamination from motor vehicle exhaust gases. It is clear that the efficient design of an engine and its optimal regulation promote both economic engine operation and a reduction in the toxicity of the exhaust gases. Methods of multiple factor experimentation design can be of assistance here as well.

When working out the engine operating conditions, one conventionally uses a number of its control parameters, the construction of which entails the

performance of on the order of 150 experiments. The application of one of the standard experiment design techniques made it possible in the case of a series produced engine to represent the data in the form of polynomial equations, the information content of which proved to be substantially higher than for the set of curves obtained using the traditional procedure. The number of trials in this instance was 24. The increase in the information content is assured by taking into account the effects of the interaction of the factors in a single equation, the capability of more precise interpolation as well as the compact and clear representation of the data. The results of the experiment were evaluated using three major engine parameters: power, operating economy and toxicity of the exhaust gases. The presence of the three output parameters makes it possible to select compromise design solutions. The polynomial equations can be run on a computer to simulate various situations, for example, that of producing the maximum power at specified levels of the operating economy and toxicity or any other combinations of requirements.

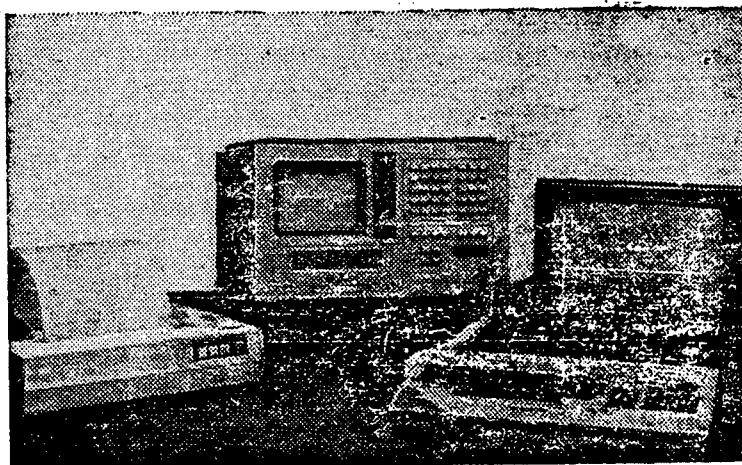


Figure 15. Laboratory variant of a computer-aided scientific research system.

The problem of designing new materials with specified properties is more complicated. In this case, the experimenter puts forward hypotheses concerning its composition and the conditions for producing it, which require experimental testing. In the final analysis, one must find the qualitative composition of the material and determine the manufacturing process conditions. Special experiment designs based on combinatorial configurations can prove to be quite useful in such situations. We shall consider a specific example. Scientists were confronted with the problem of finding the composition and recipe for a new, special-purpose polymer material. Four factors were varied. The first factor, the type of plasticizer, was varied at three levels. The second and third factors, the type of stabilizer and the amount of a certain ingredient in it, were also varied at three levels, while a fourth factor, the type of filler, had nine variations. The material was evaluated with respect to nine physical and chemical indicators as well as with respect to a generalized criterion. Completely sorting through all of the possible variants would have required 243 trials. By using special designs, the task

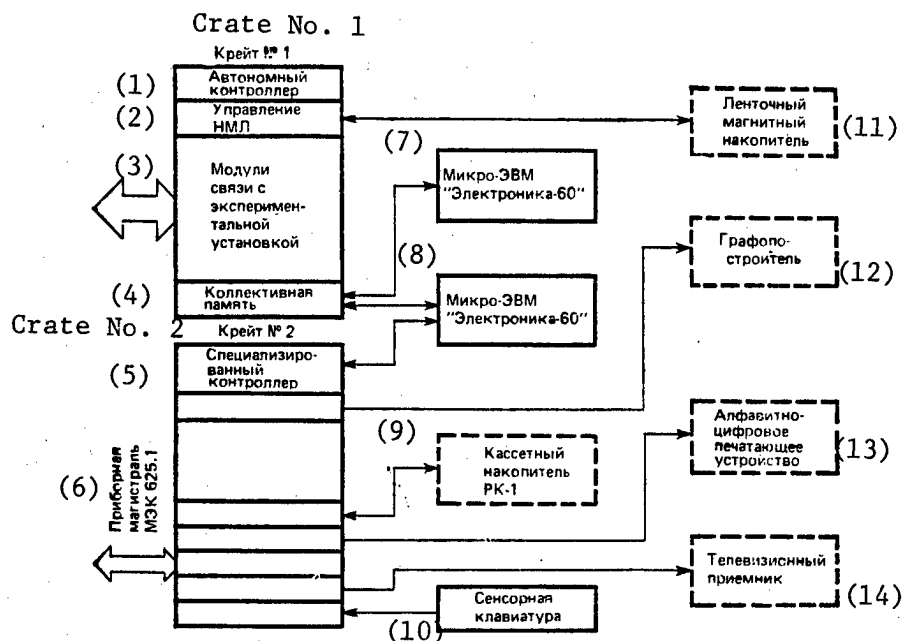


Figure 16. Radiophysics research automation system.

- Key:
- | | |
|--|--------------------------------|
| 1. Off-line controller; | 9. RK-1 cassette tape storage; |
| 2. Tape storage control; | 10. Sensor keyboard; |
| 3. Modules for interfacing with the experimental facility; | 11. Magnetic tape storage; |
| 4. Collective memory; | 12. Plotter; |
| 5. Special purpose controller; | 13. Alphanumeric printer; |
| 6. MEK [IEC] 625.1 instrument bus; | 14. Television receiver. |
| 7. "Elektronika-60" microcomputer; | |
| 8. "Elektronika-60" microcomputer; | |

was successfully accomplished with 27 trials. A material was produced that satisfied the set requirements. This new multicomponent material was successfully found in just two months in all, while two years is usually set aside for such research. Tasks of this type are characteristic of a great many research fields. These are also the search for new medications, fertilizers, animal feeds, construction materials, alloys, lubricating oils and many other mixtures.

In conclusion, we shall consider two more computer-aided scientific research system design variants. Figure 15 shows a portable laboratory version of one of the Western European real-time systems, the IN1210, for scientific data processing. The system has the following specifications:

- It is multichannel (8, 16, 32, 512, . . .);
- It is a real-time system;
- It has a multipurpose, multiuser modular structure.

The software is as follows:

- A real-time monitor for controlling the instruments during the conduct of the scientific research;
- Real-time Fortran and Basic type languages; these control the peripherals, the data collection and processing and also provide the capability of programming the modules and their expansion.

Data collection is accomplished in the system as follows:

- Through multiplexed analog inputs and outputs;
- Pulse data collection;
- A data collection frequency of up to 200 kHz;
- By the presence of amplifiers and filters.

The real-time processes are displayed by means of a color display, supplied as an add-on when requested for the laboratory version and providing for the simultaneous observation of two curves in a two-dimensional image. The system has an interactive keyboard; moreover, it is equipped with the following peripherals: a floppy disk, a hard disk with a capacity of from 20 to 300 Mbytes; magnetic tape; a high speed printer, a color digital plotter and a color hardcopy can be produced from the display screen. The system interface is an IEEE 488 (IEC); there are four RS 232C (IRPS) channels, two of which are compatible with modems, parallel inputs and outputs and can also be tied into a local area network.

The portable version of the system has eight analog inputs, a 20 Mbyte hard disk, a built-in 18 cm screen and a 1 Mbyte random-access memory.

A system for automating radiophysics research (Figure 16) is based on microcomputers and CAMAC hardware (BAKRAFI).

The system is a base-level tool which can be used as the basis for the execution of scientific research automation tasks. The BAKRAFI system provides for the automation of the collection and primary processing of the data and its recording on a digital magnetic tape store in a standard form in the experiments, employing radiophysical research techniques, with input data flows of up to 2,000 Kbyte/s. The major components of the system are:

- Two "Elektronika-60" microcomputers;
- Two CAMAC crates with a set of modules;
- Recording and display units.

Crate No. 1 performs the functions of interfacing with the experimental set-up, receiving the data and feeding out the control signals, and additionally, converting and recording the magnetic tape storage data (a type IZOT5003 magnetic tape store) in standard form, which is controlled by a programmable, high speed controller.

Crate No. 2 performs the functions of interfacing with the hardware for displaying the results of the experiment and the data on the state of the

experimental set-up. An autorecorder or X-Y plotter, several types of alphanumeric printers, and a display are used as this hardware, and additionally, it is also possible to employ an output to an MEK [IEC] type interface. The working programs of the system are fed in from a cassette tape store (type RK-1) or through a photoelectric reader in the form of a punched tape.

Crate No. 2 is controlled through a specialized controller from a microcomputer which also handles the data processing and the overall control of the entire system. For this, the microcomputer is tied into the autonomous controller of crate No. 1 through a collective memory, into which the microcomputer can also load the working programs for the controller as well as the data, while the controller can also input the data. A second microcomputer also has access to the collective memory; it is possible to add on microcomputers, which enables the parallel operation of several processors with a distribution of functions and an economic data exchange between them.

The working programs of the system are created by the user for a particular application by means of an SM-13, SM1420, etc. utility computer, equipped with RAFOS, OS RV [real-time] operating systems and special software created during the development of the system.

The system has a low power consumption, weight and small overall dimensions, which allows it to be used as a mobile laboratory.

The technical specifications of the BAKRAFI system are as follows:

The number of inputs:

--Analog inputs (+5 to -5 volts) = 32; digital inputs = 32.

The analog to digital conversion word length is 8.14.

The analog to digital converter query frequency is 200 kHz. The number of outputs is: analog outputs = 2; digital outputs = 40. There are three processors in the system. The processors are tied together through the collective memory. The type of microcomputer used is an "Elektronika-60". The CAMAC instruction generation rate by the off-line controller is up to 800 kHz.

The peripherals are:

--Two types of digital magnetic tape storage units;

--Alphanumeric printers: the DZM-180, DARO-1156 or YeS-7184;

--Plotters or X-Y recorders of any type;

--Any type of devices with an MEK [IEC] type interface output.

Conclusion

The introduction of computers into the sphere of scientific research and the automation of the research using computer-aided scientific research systems

occurred relatively recently, however, a new approach to many problems is being created because of this. Computer-aided scientific research systems have made it possible to study much more complex phenomena than could have been proposed earlier and have changed the direction and goals of many areas of science. Perhaps, the most important aspect in science is the introduction of a new way of thinking. Scientific laws are now treated as algorithms. Many of them have been studied by means of computer experiments. Physical systems are treated as computer systems that process information in nearly the same way as a computer does. As a result, it has become possible to investigate new aspects of natural phenomena and a new understanding of the problems confronting the natural sciences has come about.

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NEW MICROPROCESSOR ENGINEERING LAB OPENS IN TALLINN

Tallinn SOVETSKAYA ESTONIYA in Russian 24 Sep 86 p 4

[Article by A. Sayankin]

[Text] A microprocessor engineering laboratory opened in the Tallinn Polytechnic Institute. As a matter of fact, enthusiasm from the computer department succeeded in creating the qualitatively new interactive-computer complex which meets the highest requirement of the higher education training. In three independently equipped classes which have domestically produced computers, TPI students learn to compile microprocessor and integrated circuits, master complicated, scientific programming and make practical steps toward selected specialties. Our correspondent attended the opening ceremony of the new laboratory.

This small excursion into the world of electronics begins simply enough. Right at the entrance to the lab, guests to the Institute's festivities are asked to wear canvass slippers over their shoes. In such footwear are cordial men with the rector of TPI, academician Boris Tamm at the head, and young students from the computer department, who are wizards on the personal computer. Third year students Inna Osipyuk and Galina Belobokova willingly give a joint interview. The girls tell about the things which are difficult for the person who is uninitiated in electronics: the sum of the elements of a linear array; high, middle, and low level machine languages; digitizers;...

"But to say it more simply," Galya effectively hits the key, "we like it here very much. In the personal class, everything is at your fingertips. Having a dialogue with the computer is interesting to us. In fact, this work is truly creative."

In keeping with the moment, the words "Tere Tulemast" affably flash on the telescreens. Rector Boris Tamm, and the head of the computer department, candidate of technical sciences assistant professor Andres Keevallik, address those gathered. They tell about the great possibilities of the laboratory, its prospects, the difficulties overcome, and they thank everyone who helped the Institute in word and deed.

"Quite a number of complications came up during the creation of the microprocessor laboratory," says Boris Tamm. More than 600 thousand rubles worth

of various allocations were acquired for the apparatus. By their own efforts, they carried out a large volume of assembly work. So here we have one of the best VUZ microprocessor laboratories in the country. In the personal computers class, all the conditions are created for students for productive, thoughtful work. Each person can check his own program and adjust those already existing. In the room for computer programming of microprocessors and integrated circuits, it is possible to assign the computer very different variables and produce high-quality diagrams and pictures for printed sheets, and solve many problems, which are associated with the large volume of computation.

The third class is equipped with microprocessor simulators. With their help, the students learn to set up complicated numerical systems for operation by means of several processes. And not even the most penetrating and beautiful words will take the place of those of practical skills, which future computers will generate within the walls of the new laboratory.

By the way, skills obtained during the creation of the Institute's complex, in due course helped students graduating from TPI, Peter Ellervee and Aleksandr Maksimenkov, achieve great successes in the last years' All-Union competition of science students works in computer science. Peter took first place at it and Aleksandr--third.

The Institute's festivities are over. The young specialists in the computer department are in an elated mood. Thanks to their enthusiasm, clearness of purpose, energy, and diligence, this laboratory came into being at TPI. Another important thing: one more practical step toward rebuilding the educational process has been made for the student body of a leading technical VUZ in the republic.

PHOTO CAPTION

Work is in full swing in the class on personal computers. Here studies go about in computer design. Photo by K. Liyva

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