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13 June 1980

USSR Report

CONSTRUCTION AND EQUIPMENT

(FOUO 5/80)

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BUILDING MATERIALS

USE OF TILES, GLASS IN CONSTRUCTION REVIEWED

Ceramic Tiles

Moscow STEKLO I KERAMIKA in Russian No 2, 1980 pp 2-3

[Article by Chief Manufacturing Engineer A. A. Farsiants of the Ceramics Industry Administration of USSR Ministry of Construction Materials: "Raising Production Effectiveness in the Construction-Ceramics Industry"]

[Text] The drive to raise production effectiveness and work quality is the main trend in the CPSU's modern economic policy. The following tasks face our industry at this time: to increase volume of output from existing capacity, to increase yield from the funds that have been invested, to reduce the materials and labor expended per unit of finished product and to raise product quality. Questions of the integrated mechanization and automation of production, a reduction in the share of manual labor, mechanization and automation of production, and the grading and packing of products acquire special importance.

Reequipping with machinery has been going on for the past 10-15 years in the construction-ceramics industry, especially in the production of all types of ceramic tile. Almost all enterprises have converted from the dry method of preparing the powder press to the slip method, using spray dryers, and at some plants continuous-action mills for breaking up the clay have been introduced. Kilning of the tiles in tunnel kilns for saggars has been replaced by kilning on conveyor flow lines with roller-hearth furnaces. Such labor-intensive operations as filter-pressing the slip, drying clay in drums and repeated manual rearrangement have been precluded. The work of NIIstroykeramika [Scientific-Research Institute for Construction Ceramics], which is used in Giprostroymaterialy [State Institute for the Design of Building-Materials Enterprises] designs and then is introduced into the industry, is playing a major role in reequipping the industry with machinery.

A most important factor in raising production effectiveness and work quality is growth in labor productivity. Raising labor productivity at construction ceramics enterprises by 1 percent will yield an increase of

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300,000 rubles' worth of products and will also allow 50-60 people to be released provisionally per year.

The main resource for an upsurge in labor productivity is acceleration of scientific and technical progress. The assimilation of new, highly productive machinery and technology will enable more output to be produced with fewer workers. The introduction of conveyor flow-line technology for manufacturing ceramic tiles will aid greatly here. At present about 200 such lines are in operation at the enterprises, which are producing more than 40 million square meters of ceramic tile per year.

The serial production of conveyor flow lines and of spray dryers has been mastered at Bologovo's Strommashina plant, Kemerovo's Strommashina plant of USSR Minstroydormash [Ministry of Construction, Road and Municipal Machine Building], and the Perm' Machinery Test Plant of USSR Minstroymaterialov [Ministry of Construction Materials Industry].

At practically all newly built or rebuilt plants conveyor flow lines for producing all types of ceramic (facing, floor and facade) tiles have been installed and are in operation. The introduction of these lines enabled more than 800 persons to be released and about 16 million rubles per year to be saved and also permitted the variety of products to be expanded and the quality thereof to be improved.

Taking into consideration the experience gained in operating the first lines, which had an annual productivity of 250,000 square meters of facing tile, 200,000 square meters of floor tile and 100,000 square meters of facade tile, conveyor flow lines of greater capability--with productivities, respectively, of 500,000, 400,000 and 300,000 square meters of tile per year--were created.

The next step was the creation of lines with an annual capacity of 800,000 square meters of floor tiles and 700,000 square meters of facing tiles. The first models of these lines were installed at the Khar'kov Tile Plant and the Slavyansk Ceramics Combine. Unlike previous designs, these lines were assembled from unified sections, which is very important during assembly and operation.

A basically new conveyor flow line with a capacity of 100 square meters per hour, or more than 800,000 square meters of facing tile per year, is now being created. This line will include highly productive presses, vertical dryers, an improved glazing installation, and automatic machinery for grading and packing the finished output.

The country's first conveyor flow line for producing large-dimension (0.5x1x0.01 meter) Plink plates in accordance with a technology developed by NIIstroykeramika is being mastered at the Kuchinovka Ceramic Facing-Materials Combine.

Major attention has been devoted in recent years to operation of the enterprises' large-scale preparation departments; cutting and flinging mills

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for breaking up clayey materials are being used and improved spray dryers are being introduced, enabling powder output to be about doubled.

Much is also being done to supply bathroom ceramic products. Almost all plants have converted to the production of sanitaryware made of bulk porcelain with a water absorption of 0.5-1.0 percent. These products are hygienic and are distinguished by high strength, they are not vulnerable to the effects of aggressive liquids, and they are more durable. While about 5 million articles were manufactured out of bulk porcelain in 1975, about 7 million pieces are to be produced in 1980. By the end of the Eleventh Five-Year Plan all sanitaryware will be manufactured from bulk porcelain.

The national-economic plan for new technology calls for a further increase in the production of colored sanitaryware; in 1980 output thereof will be 350,000 units. Much remains to be done in subsequent years to introduce modern designs for colored sanitaryware. NIIstroykeramika, the Institute of Esthetics and NIIsantekhnika [Scientific-Research Institute for Sanitary-Engineering Equipment] are developing bathroom and restroom interiors of modern design. Much work on the introduction of new articles is being done at the Kuybyshev and Lobnya plants for construction porcelain. Almost all the large plants that produce sanitaryware are equipped with glazing conveyors, whose use raises output quality substantially.

Mechanized rigs for the manufacture of lavatories and toilet bowls are now being created and introduced. The use of such rigs not only eliminates heavy manual labor but also enables the output of a wide assortment of articles. The introduction of mechanized rigs combined with swinging-tray dryers and glazing conveyors will enable the flow-line production of sanitaryware to be established.

Raising production effectiveness is impossible without the rational use of raw materials and other materials, and fuel and energy. In recent years the raw-materials base has been greatly expanded through the discovery of new deposits (the Fedorov deposit in Rostovskaya Oblast, the Pechora in Pskovskaya Oblast, the Cambrian in Leningrad, the Tankerovskoye in Tselingradskaya Oblast, the Angren in Tashkentskaya Oblast, and other deposits). The use of local types of raw materials is of great national economic significance. A reduction in the average hauling radius by 100 km will enable an annual saving of about 1.5 million rubles.

The mechanization and automation of processes in auxiliary departments, especially for loading and unloading, where the share of poorly productive manual labor still is great, are reserves for labor-productivity growth. The first model of a grading and packing installation for a line with an annual productivity of 800,000 square meters of floor tile that will be installed at the Khar'kov Tile Plant was manufactured at a NIIstroykeramika test plant during the fourth quarter of 1979 in accordance with that institute's developments.

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Work to mechanize processes is also being done at a number of plants. Thus the Voronezh and Minsk enterprises have tested a container for packing and transporting ceramic tile, and at Shchekino's Kislotoupor plant acid-resistant articles are being packed on pallets and bound by a metal strap.

In implementing 25th CPSU Congress decisions, the CPSU Central Committee and the USSR Council of Ministers adopted the decree, "Improvement of Planning and Intensification of the Effect of the Economic Mechanism for Raising Production Effectiveness and Work Quality." This decree is aimed at further improving and intensifying planning supervision of the economics activity and at developing democratic principles in management and creative initiative in laboring collectives.

The decree attributes paramount importance to further improving long-range planning, developing a mutually related system of plans and transforming the five-year plan into the main form of planning for the national economy.

The compilation of annual plans should be started from below (at enterprises and associations), based upon a search for the reserves that are uncovered by socialist competition and counterplans.

When substantiating the ministry's draft plans, economic and engineering calculations will be used, as well as rating sheet data for each association and enterprise, and so rating sheets are to be made up in 1980. They will call for information about the existence and level of use of capacity and growth of the shiftwork-utilization factor of the equipment, as well as measures for specializing production.

Tasks for mastering and introducing new equipment should become an organic part of production and of capital construction. The creation of new enterprises and the reconstruction of existing ones should be executed on the basis of highly effective technology and use of the newest equipment that will provide for the output of products that correspond to the best domestic and foreign models.

The stimulating role of resources of the single fund for developing science and technology that is established in ministries and agencies through deductions from profit is to be intensified.

Much work must also be done in the ceramics industry to fulfill the tasks indicated in the decree. It is planned to perform work on further reequipping the industry with machinery. For this purpose it is desirable right now to inspect existing industrial processes and installed equipment with a view to replacing them with more effective and modern processes and equipment.

The time has now come when some enterprises must replace low-capacity conveyor flow lines with those that are more productive (from 500,000 to

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1 million square meters per year), and the modernization of existing conveyor flow lines should be stipulated with a view to using secondary heat.

Major attention will be devoted during the Eleventh Five-Year Plan to expanding the variety and raising the quality of output. Therefore, it is necessary to use more widely new bulk material and glazing compositions and to introduce progressive methods for applying glazing. A 1-percent reduction in losses to scrap will yield a growth in product output of more than 3 million rubles, not to speak of the additional profit obtained.

In order to reduce the operating costs of output, it is desirable to use more widely local raw materials and those materials that are not in short supply.

The industrial process at enterprises that produce ceramic tile is to be completely automated with the introduction of ASUTP [automated system for the control of industrial processes] for the process stages between the slip and the warehouse for finished products. Industrial processes in bulk-material set-up departments and at auxiliary production facilities must be mechanized and automated to the maximum.

Major tasks face the construction-ceramics industry. All efforts to solve them successfully must be applied.

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Use of Glass Grows

Moscow STEKLO I KERAMIKA in Russian No 3, 1980 pp 29-30

[Article by G. M. Matveyev and Kh. G. Yaroker, candidates of engineering sciences of VNIIESM [All-Union Scientific-Research Institute for Scientific Information and the Economics of the Building Materials Industry] and TsNIIpromzdaniy [Central Scientific-Research and Experimental Design Institute for Industrial Buildings and Structures]: "Raising the Utilization Effectiveness of Glass in Construction"]

[Text] An All-Union conference dedicated to raising the production effectiveness and use of glass and materials and articles based on glass in construction was held in Gomel' in 1979. This is the first All-Union conference at which manufacturing engineers and builders jointly reviewed questions of glass utilization effectiveness in construction. Participating in the congress were 130 representatives from 55 different organizations, ministries, agencies, associations and educational, design and scientific-research institutes, as well as glass plants. Reports were heard at plenary sessions on the more urgent questions of making glass and using it in construction.

Director of VNIItekhstroysteklo [All-Union Scientific-Research Institute for Construction-Glass Technology] Candidate of Engineering Sciences A. G.

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Shabanov reviewed the status of and prospects for developing the production of construction glass. Our country's glass industry is manufacturing more than 300 million square meters of construction glass each year. The USSR ranks first in the world in output of window glass.

The variety of construction glass is constantly being expanded. The production of colored, safety and plate glass, glass section, window glass, devitrified heat-absorbing glass and glued double-glass panes by the mechanized method, and of Metelitsa decorative glass has been mastered. In the near future it is proposed to organize the large-scale production of new solar-protection glass, double glass panes and other glasses in the near future. The reporter pointed to the importance of experimental construction for checking comprehensively the operational qualities of new articles, and he noted the necessity for more precise determination of construction's requirements for new articles made of glass.

The report of GIS [State Institute for the Scientific-Research of Glass] Deputy Director Candidate of Engineering Sciences L. L. Orlov was dedicated mainly to development of the production of facing articles made of glass: flooring tiles, marble glass, enamel-coated decorative glass and other glasses.

He dwelt in detail also on questions of reducing losses of window glass and of increasing the utilization effectiveness of glass cut to size. By the end of the Tenth Five-Year Plan, the annual output of glass cut to size is to be about 150 million square meters, or almost half of all window glass production. However, because of the large number of standard sizes of glass sheets called for by existing standards and by standard designs for windows, customers frequently order the sheets in larger sizes. At the construction site this leads later to recutting of glass that is shipped by plants as glass cut to size. Window structure must be unified, in order to raise the utilization effectiveness of sheet glass in construction.

Deputy Minister for the Belorussian SSR Construction-Materials Industry Candidate of Engineering Sciences S. S. Akulich reviewed the prospects for expanding the production and use in the national economy of glass pipe made of heat-resistant and borosilicate glass. The use of 1 km of glass pipe will allow more than 7 tons of metal pipe, including 3 tons of stainless-steel pipe, to be saved (taking service life into consideration). During the Ninth Five-Year Plan the tentative economic benefit from introducing glass pipeline was about 450 million rubles. The reporter dwelt in detail on choosing an optimal technology for producing such pipe.

The report of Deputy Chief of USSR Gosplan's Glavpromstroyproyekt [Main Administration for Industrial-Construction Design] Candidate of Engineering Sciences Ye. G. Kutukhtin was devoted to questions of using glass in industrial construction. He noted that window structure influences considerably the economic indicators of buildings, helps to provide the required microclimate and sanitary and hygienic conditions for working and

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personal amenities within a premise, and helps to shape the architectural appearance of facades and interiors. Designs for window sash are constantly being improved. Hot-rolled steel section used in sash is being replaced by bent thin-walled tubular sash, which enables metal consumption to be reduced by 10-20 kg per square meter of window and the sash's load-carrying capacity to be raised.

Ye. G. Kutukhtin dwelt in detail on the unification of window structure. Some 150 standard sizes of glass are now being used for industrial construction, 25 of them providing 80 percent of the total requirement for window glass. USSR Gosstroy has approved a products mix of windows and doors made of wood and of steel and aluminum alloys that is unified for all types of construction. Structure for windows for various types of buildings, based upon the approved products mix, is being developed that will enable the number of standard sizes for glass to be reduced severalfold.

The report devoted major attention to reducing heat loss through translucent barrier structure, including the use of double-pane glass and other special types of glazing. The reporter pointed out the effectiveness of introducing sash-free translucent structure, created on the basis of glass section and glass blocks, into industrial construction, and he also examined questions of improving the quality and of raising the utilization effectiveness of these articles in construction.

Architect V. N. Alekseyev (TsNIIEP zhilishcha [Central Scientific-Research and Design Institute for the Standard and Experimental Design of Housing] of USSR Gosgrazhdanstroy [State Committee for Public Building Construction and Architecture]) delivered the report, "Effective Articles Made out of Glass and Their Role in Modern Architecture." He analyzed in detail the factors that restrain the use of new types of glass in construction, namely: the low quality of some products, the lack of outfitting materials, unsatisfactory information about new articles made of glass and about structure that incorporates them, and the inadequate economic incentives for producing and using such articles.

Four sections operated at the confernece. The section, "Translucent Enclosure for Buildings," which Ye. I. Kutukhtin headed, examined questions of the effectiveness of production and the use in construction mainly of plate glass and of articles made of it.

The reports of candidates of engineering sciences Yu. P. Aleksandrov (TsNIIpromzdaniy) and G. I. Khavaldzha (TsNIIEPsel'stroy [Central Scientific-Research and Design Institute for the Design of Standard and Experimental Rural Construction] analyzed questions of using glass in industrial and agricultural construction. Yu. P. Aleksandrov dwelt on the advantages of using skylights for natural illumination of the premises of industrial and social buildings.

The section's work devoted major attention to the utilization effectiveness of various solar-protection glasses. Manager of VNIItekhstroysteklo

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laboratory B. Ye. Romanov told about new types of solar-protection glasses, the industrial mastery of which is proposed for the near future at the Saratov Plant for Engineering Glass.

Candidate of Engineering Sciences Ye. I. Semenov (TsNIIEP zhilishcha) reported that the resistance to heat transmission of windows in which one of the panes has a stannous-oxide coating is 20 percent higher than of windows made of ordinary glass. According to the researchers' data, this will enable a substantial economic benefit to be obtained. The reports of candidates of engineering sciences S. I. Belyanovskiy (TsNIIEP zhilishcha), O. V. Vorob'yev (GIS), S. P. Solov'yev (TsNIIEP uchebnykh zdaniy [Central Scientific-Research and Design Institute for the Standard and Experimental Design of Educational Buildings]) and physicist T. G. Khalatova (TbilZNIIEP [Tbilisi Zonal Scientific-Research and Design Institute for the Standard and Experimental Design of Housing and Social Buildings]) revealed the utilization effectiveness of various solar-protection glasses. T. G. Khalatova pointed out the high operational qualities of new heat-absorbing glass developed by VNIItekhstroysteklo.

Candidate of Engineering Sciences A. G. Shabanov dwelt on the prospects for organizing the mass production of hardened glass for construction. The section also discussed questions of the strength of glass and the production and use of double-pane glass and other effective articles made of glass.

The section, "Facing Materials Based on Glass and Devitrified Glass," reviewed questions of the production and use of both basically new and of traditional facing materials.

Candidate of Engineering Sciences N. N. Semenov (VNIItekhstroysteklo) reported about a method of electrochemical tinting of plate glass that his institute developed that can be used as facing material.

The Vladimir Polytechnical Institute and the Gusev Plant imeni F. E. Dzerzhinskiy are doing work to raise the decorative qualities of glass section. S. V. Didenko told about the results of the work.

Some reports of GIS staff workers were dedicated to the perfection of a technology for producing flooring tiles, marbled glass, decorative glass crumb, enamel-coated glass and other facing materials. The necessity for creating new shaping methods and for developing modern highly productive equipment for the manufacture of facing articles was noted. Reports about the work being conducted by GIS and the Kherson Glass-Products Plant to form strips of opacifying glass on a one-roll machine provoked great interest. The upper part of the strip is formed here under the action of surface-tension forces, improving product quality considerably.

This same section heard the reports of candidates of engineering sciences G. V. Rezenko (the Avtosteklo plant) and V. F. Lyasin (the Leninist Glass Plant) about mastering the production of new articles--marbled and ceramic glasses--and about raising the quality of other construction articles made

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of glass. Also examined were questions of improving the quality of ornamented and safety glass, the share of which in the total output volume of construction glass is constantly rising.

Joint sessions of the sections on, "Heat Insulated and Heat-Protective Materials Based upon Glass," and "Glass for Constructional Structure and Building Materials" were held at the conference. Doctor of Engineering Sciences P. D. Sarkisov headed the work of the sections. During this session much attention was devoted to questions of obtaining foam glass. In particular, MKhTI [Moscow Engineering-Physics Institute] imeni D. I. Mendeleyev and NIIavtosteklo [Scientific-Research Institute for Motor-Vehicle Glass] have done research on the foaming of glass, and NIISM [Scientific-Research Institute for Building Materials] has obtained decorative facing glass--decorative and acoustic foamed glasses.

Several reports were dedicated to the use of fiberglass materials such as reinforcement for glass-cement and the production and use of glass pipe and products made of artificial stone.

Reports about work being done in the Brest Construction-Engineering Institute on the enameling of construction articles and in the Belorussian Industrial Institute on the synthesis of new glasses and devitrified glass stimulated interest.

The sections adopted recommendations on the basis of which the decision of the All-Union conference was worked out.

The conduct of the conference and the realization of its decisions will help to expand the use in construction of effective articles made of glass.

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METALWORKING EQUIPMENT UDC 621:658:566

SUPPLY, MATERIAL SAVINGS AT MACHINE-BUILDING ENTERPRISES

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 1, Jan 80 pp 69-71

[Article by Candidate of Economic Sciences L. M. Striyer]

[Text] One of the conditions for further improvement of savings in production by machine-building enterprises is an efficient organization of their supply of materials and equipment. The quality of the supply can be judged according to the actual state of the production stocks of the enterprises. The present system of organization of materials and equipment for production and the level of development of economics mean that in each separate case the volume (norm) of necessary and sufficient production stocks can be determined with sufficient accuracy for each enterprise according to its physical resources.

Each deviation of the amount of production stocks from the calculated normative level causes definite losses that reduce the production efficiency. A direct calculation of these losses is impossible because the accounts of the enterprises do not have the data characterizing the costs of the supply of materials and equipment. To construct indicators for the costs of maintaining above-standard productive stocks and the losses due to a deficit in materials requires that special calculations be performed and the data in the initial accounts be analyzed and rearranged.

The losses due to the presence of above-norm stocks in warehouses are a part of the cost of maintaining all the productive stocks. The latter combine various expenditures of the labor, material, and financial assests of the enterprises. Depending on how they are reflected in the economic indicators of the operation of the enterprises, they are divided into

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the costs of storing materials and are included in the production losses or the costs associated with the immobilization of working capital in reserves of commodity stocks that are subtracted from the profits of the enterprises.

The costs of maintaining production stocks are divided into two groups for another reason: the indicator for the storage costs can only be derived by analyzing the initial accounting data, while the immobilization costs can be obtained from calculation.

The costs of storing the production stocks include the expenditures for the labor, materials, and energy involved in the storage process itself, for maintaining certain conditions in the storehouses, for guarding and moving the stored materials, for preserving their qualities, etc., and also the wages of the supply workers and the packing outlays.

The costs associated with the immobilization of capital invested in physical reserves are potential losses arising from the impossibility of obtaining a certain volume of profits since the commodity stocks are tied up. This is the so-called missing profit in the economy. From the standpoint of the expenditures by an enterprise for maintaining materials, the specific costs associated with the presence of stocks in warehouses are of interest. This includes the charges for working capital in production stocks and payments to the State Bank for credits used for production stocks.

The total costs of maintaining production stocks are not limited to the expenditures listed above. Thus, the storage of raw and finished materials is the reason for budget payments to cover the fixed productive capital for storage operations; many sections in a enterprise - the planning and financial departments, bookkeeping, office workers, personnel section, etc. - carry out certain functions, whose cost can be assigned to stock maintenance. These expenses, just as the wages of the supervisors in the supply section, are assigned to nominally constant expenditures that are independent of the volume of the physical assests being stored. Therefore, if the losses from the maintenance of above-norm productive stock are to be determined, only the total of the nominally variable costs must be calculated.

This model was used to calculate the costs of maintaining the productive stocks of the Tbilisi enterprises: the Elektrovozostroitel' PO [production association], the Machine Tool Plant imeni S. M. Kirov, and the Gruzsel'mash Plant.

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Indicators	Elektrovozostroitel' Assoc.	Kirov Machine Tool Plant	Gruzsel'mash Plant
Actual annual average value of productive stocks, thous. R	7955	5317	1384
Costs of maintaining productive stocks, thous. R	1012.0	762.3	190.4
Costs of maintaining a stock unit, R/thous. R	127.2	143.4	137.5
Level of productive stocks as percent of norm	121.6	117.3	127.0
Normalized average annual value of productive stocks, thous. R	6541	4530	1098
Costs of maintaining normalized value of productive stocks, thous. R	832.0	649.6	150.9
Losses due to maintenance of above-norm productive stocks, thous. R	180.0	112.7	39.5

A direct calculation method can be used to determine the losses due to above-norm productive stocks in an enterprise. A preliminary calculation of the indicator of the costs of maintaining a stock unit is performed by dividing the total value of the stock maintenance costs over a certain period by the average stock value. This indicator describes the quality of the work of the supply department and makes it possible to compare the organization of the maintenance of raw and finished materials at different enterprises. In our investigation, it was used to determine the loss due to above-norm stocks. For this purpose, the indicator of the costs of maintaining the actual value of the productive stocks was first derived by sampling the initial accounting data. Table 1 shows a calculation of the yearly indicator of the costs of maintaining a stock unit; it was used to determine the calculated value of the costs of maintaining the normalized level of productive stocks and, as the difference with the total costs of maintaining the actual value of the stocks, the additional expenses of an enterprise in maintaining that part of the productive stocks above the established norm.

The loss indicators obtained do not pretend to be absolutely accurate: the stock maintenance costs do not necessarily grow in direct proportion to the increase in the value of the

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production stocks; different product lists of stocks require different maintenance costs per stock unit. Nevertheless, the results obtained give an idea of the magnitude of the costs associated with above-norm productive stocks.

Above-norm surpluses of commodity stocks carried over from year to year indicate constant losses for their maintenance. The presence of above-norms stocks also suggests certain economic losses because the raw and finished materials cannot be used by other enterprises. The losses can easily be calculated by using the efficiency index suggested by the Scientific-Research Institute of the Economics and Organization of Material and Technical Supply of the USSR Gosnab for the assets allocated by enterprises. On the whole, this coefficient equals 0.21 for industry.* This means that each ruble invested in industrial kopecks per year. As a result, the losses to the economy come to 210 R for each thousand rubles of above-norm production stocks per year, i.e., they are more than a factor of 1.5 above the maintenance costs per stock unit in the enterprises surveyed. Moreover, the raw and finished materials frozen in warehouses increase the deficit of these types of labor assests on a country-wide scale.

As the present investigation has shown with regard to the presence of a fairly large amount of above-norm productive stocks in a certain category, the enterprises must still bear heavy losses due to the lack of other types of physical resources at the needed moment.

At practically every industrial enterprise, difficulties in production supply arise periodically due to the lack of productive stocks required for current consumption at the needed time. During the investigation, there were stoppages in receiving a number of materials that had a considerable effect on the fulfillment of the production programs, including product assortment.

The continuation of productive output under shortage conditions involves the carrying out of unplanned measures requiring additional expenditures, which are losses for the enterprises, since they would not occur if the productive stocks of raw and finished materials were present in the required amount and

*Standard sampling technique for direct shipment or storage of products used for industrial or technical purposes by the industrial enterprises. Moscow, NIIMS, 1967, p. 16

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variety. The measures include the efforts of the supply workers to find additional sources of productive stocks and to organize an accelerated input of the insufficient materials, where the losses appear in the form of additional out-of-town, telephone and telegraph, and transportation expenditures for accelerated shipment of the critical goods. Other measures aim at continued manufacture of products by replacing the missing materials with substitute materials or by large-scale purchases of available materials. In this case there are losses associated with the carry-over of materials and the wages of workers processing the extra volume of materials, purely material losses due to the use of more expensive brands in production, and the losses of labor resources associated with design changes in the specified products. In cases where substitution is not possible, the planning targets are sometimes ignored, and the output consists of products planned for a latter time. As a result, some of the expected profits are not received, and there are losses due to payment of penalties for late shipment of goods.

Any operations designed to eliminate the shortages cause financial losses to the consumer enterprise. These additional expenditures are recorded in the primary accounts of the enterprises. Cases of substitution for missing product assortments are recorded on documents, supplemental payments to the operating norms and appraisals are recorded in special supplementary payment documents and orders, the difference in costs between accelerated and normal shipments can be determined from the appropriate accompanying documents, and, finally, the additional mail, telegraph, and out-of-town expenditures can be determined from the accounts. It turned out that for only one year the Elektrovozostroitel' PO incurred losses on the order of 460,000 R due to material shortages; losses for the Kirov and Gruzel'mash plants were 172,000 and 82,000 R, respectively.

Expenditures to replace missing production stocks predominate in the structure of the losses due to material shortages at all the enterprises. Over the course of a year, the enterprises made active use of available materials for missing ones. The production tempo was not often interrupted because of an artificially produced shortage in the next year. Planned production can continue because the source of the additional materials is the above-norm surplus of physical resources that is available at every enterprise. The subsequent buildup of the production stocks, which often occurs when the acute need for them has passed, again brings the above-norm surpluses to the previous level.

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The significant excess of materials carry-over (322,000 R) compared to wage carry-over (4,000 R) at the Elektrovozostroitel' PO is due to the frequent replacement of materials by more expensive grades, which usually did not require additional labor input. The wage losses due to shortages are largely associated with the manufacture of parts from the large-scale stocks. Therefore, it is not accidental that at the Kirov Machine Tool Plant, where ferrous metals are 80% of the production input, the wage carry-over due to shortages (6.96 thous. R) is the largest among the enterprises investigated, both absolutely and relative to the total losses.

Unplanned transportation and procurement expenses due to the search for addition supply sources and the organization of acclerated shipment of materials are fairly large at all the enterprises (30,000 to 56,000 R). This reason is the frequent use of external measures to eliminate the deficit. Thus, the shortage of ferrous metals at the Elektrovozostroitel' PO was three-fourths covered by shipments from various sources, and during the entire year the Gruzsel'mash plant experienced difficulties in obtaining parts for complete sets. During the period investigated, all the enterprises paid the buyers of their production considerably higher penalties then they received from their suppliers. However, the uncompensated part of the fines is many times lower than the losses the enterprises would bear if the planned production were attempted without the required materials.

The total amount of financial losses due to shortages at all the enterprises does not contain the losses associated with that part of the profit not received from the unfinished and thus unrealized production which was suspended because of a shortage of required materials. These losses are compensated by the shipment of products of different description, often with a much higher profitability. In this manner the plan for profits was filled and overfilled. The present monetary sanctions do not seriously affect the economic interest of the manufacturers. Thus, the Elektrovozostroitel' association paid a year's fines worth 6% of its balance-sheet profits, the Gruzsel'mash paid 2%, and the Kirov plant paid 1.1%. These figures indicate the low efficiency of the claims work done under the present statute on production shipments. Therefore, such losses due to shortages are either not present at industrial enterprises at all or are quite insignificant. The consumer enterprises, as a result, must bear additional expenditures, which, as we saw in the enterprises analyzed above, are many times larger than the total fines.

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Indicators	Elektrovozostroitel' Assoc.	Kirov Machine Tool Plant	Gruzsel'mash Plant
Actual production cost of the commodity products, thous. R	36,121	23,735	11,378
including:			
losses for storage of above-norm stocks	83.38	49.98	19.00
material losses for substitutes due to shortages	322.84	56.88	35.48
wage losses due to shortages	4.00	6.96	2.13
losses due to shortages in general plant expenditures	34.90	56.82	30.21
Total losses	445.12	170.64	86.82
Actual balance sheet profits, thous. R	4627	5769	3472
Reduction in profits as a result of losses, thous. R:			
from sales	445.12	170.64	86.82
due to immobilization of above-norm stocks	96.62	62.67	20.50
fines for physical shortages	98.68	52.58	14.66
Total losses	640.42	285.94	121.98

Losses due to an insufficiently efficient organization of the supply of materials and equipment affect most of the indicators of the enterprises' operation. A quantitative estimate of these losses is possible because of the ultimate reflection in the most important cost indicators - production cost and profit.

The presence of above-norm stocks in the enterprises affects the production costs through the general plant expenditures, in which the maintenance costs are reflected. A deficit of certain production stocks leads to additional expenditures by the enterprises in order to continue production when the resources are insufficient, and they either increase the production cost of the entire production or part of it, depending on the type of measures undertaken to eliminate the shortage. In particular, the replacement of missing stocks leads to a carry-over of materials and wages, and this is reflected in an increase in the production cost of those parts whose manufacture required the missing materials. Thus, the losses due to substitutions for shortages are similar in nature to direct expenditures for production, including the production cost. The unplanned

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expenditures by supply sections in the enterprises in order to organize rush shipments of needed materials are indirect costs. They are included in the general plant expenses and increase the production cost of all the products. Table 2 shows the effect of individual items of expenditure for maintaining above-norm productive stocks and losses due to a shortage of materials on the production cost of all the commodities produced during the period under study.

Inefficient organization of the supply of industrial enterprises that increases the production cost reduces the profit from its realization, which is the principal item in the balance-sheet profit. Therefore, the losses from the deviation of the stocks from the norm, which are reflected in the production cost, affect the amount of the balance-sheet profit. In addition, part of the costs of maintaining the production stocks and certain losses due to shortages are directly subtracted from the balance-sheet profit of enterprises operating under the conditions for planning and economic incentives. This applies to payments to the budget for working capital to put in commodity stocks and a percentage payment for credits for production stocks, and also the imminent penalty payments for late, low-quality, and incomplete shipments of products that occur because of a shortage of raw and finished materials. Part of the costs of immobilization of assets in productive stocks that reflects the above-norm portion and the fines paid for violation of contract obligations are losses to the enterprises due to the deviation of the stock from the norm, which are not included in the production costs. The effect that losses of material and equipment supply have on the balance-sheet profit is shown in Table 2.

Thus, the presence of above-norm surpluses of physical assests and the simultaneous shortage of certain stocks of raw and finished materials cause appreciable material losses. These losses not only increase the cost of production but also have a substantial effect on the most important indicators for the operation of the interprises. They can be reduced and then eliminated by improving the organization of the supply of materials and equipment and by making the practical application of scientific methods of controlling productive stocks a primary goal

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METALWORKING EQUIPMENT

MACHINE TOOL INDUSTRY, NUMERICALLY CONTROLLED MACHINE TOOLS EXAMINED

Progress Summarized

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 80 pp 1-2

/Article: "Machine Tool Builders by the 110th Anniversary of the Birth of V. I. Lenin"/

/Text/ The workers of the machine tool and tool building industry, like all the Soviet people, are greeting the 110th anniversary of the birth of V. I. Lenin with new labor achievements.

Guided by the decisions of the November (1979) CPSU Central Committee Plenum and the decree of the CPSU Central Committee, "On the 110th Anniversary of the Birth of Vladimir Il'ich Lenin," the collectives of the production and scientific production associations, enterprises and organizations of the sector have assumed socialist obligations which are aimed at the increase of efficiency and work quality, the increase of labor productivity, the quickest possible introduction of the results of scientific and technical progress in production, the improvement of planning and the tightening up of organization and discipline.

The Moscow Machine Tool Building Plant imeni Sergo Ordzhonikidze, the Leningrad Machine Tool Building Production Association imeni Ya. M. Sverdlov, the Ryazan' Machine Tool Building Production Association and other leading enterprises of the Ministry of the Machine Tool and Tool Building Industry were the initiators of the anniversary socialist competition in the sector.

The socialist obligations for 1980 provide for the following main measures: the sale of products in excess of the plan worth 15 million rubles; the production for the national economy in excess of the plan of 300 machine tools (including 100 machine tools with numerical program control), metal-cutting tools (including diamond tools) worth 1.5 million rubles, reducers and standardized items worth 700,000 rubles; the attainment in 1980 of an overall increase of production at operating enterprises by the increase of labor productivity without increasing the number of workers.

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Stepped-up obligations on the acceleration of the rate of scientific and technical progress and the improvement of the structure of the equipment being produced, the most important of which are cited below, have been adopted for 1980.

By the 63d anniversary of Great October to produce 3,415 test models of new types of highly efficient equipment and items, to assimilate 3,120 adjustment series.

To ensure the early development and assimilation of machine tools, machines, equipment, instruments and automation equipment with a productivity not less than 1.5-fold to 2-fold greater as compared with the 1975 level.

To increase as compared with 1979 the output of test models and adjustment series of new highly efficient machine tools with numerical program control by 12.4 percent, machine tools of especially high precision by 12.6 percent and automatic and semi-automatic machines of all technological groups by 6 percent.

To increase the output of machine tools with numerical program control in 1980 to 6,000 units, including machine tools with the automatic changing of tool to 2,800 units.

To produce and perform the adjustment and testing of two automated sections of models ASV-22 and ASK-11 from machine tools with numerical program control, which are controlled by computer.

The assimilate the output of the adjustment series of 35 models of automatic and semi-automatic forge and press machines of all technological groups, 5 models of forge and press machines and units with program control, 20 models of forge and press machines and units for obtaining precision blanks and 7 models of heavy-duty and unique forge and press machines.

To produce ahead of time quickly readjustable automatic lines with numerical program control (two units), which consist of semi-automatic lathes of model 1B732F3 and automatic manipulators with program control; a unit consisting of three automated lines (for assembling tractor engines), the use of which will increase the productivity of assembling 2.6-fold; a unit consisting of five automatic lines, the use of which for the machining of parts of motor vehicles will make it possible to release 134 general-purpose machine tools and about 270 workers.

By the 110th anniversary of the birth of V. I. Lenin to produce the test models of milling machines (made by the Odessa Plant of Milling Machines imeni S. M. Kirov, the Vil'nyus Komunaras Machine Tool Plant and the Dmitrov Plant of Milling Machines) with small devices for numerical program control on the basis of microcomputers, which ensure the preparation of the control programs at the workplace.

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To produce the test models (the Sterlitamak Machine Tool Plant imeni V. I. Lenin, the Gomel' Machine Tool Plant imeni S. M. Kirov, the Molodechno Machine Tool Plant) and the adjustment series (the Odessa Plant of Precision Machine Tools imeni XXV s"yezda KPSS, the Vil'nyus Zhal'giris Machine Tool Plant) of multitool machine tools with numerical program control, which are built according to the standard-unit principle from standardized assemblies and ensure an increase of productivity by 2-fold to 3.5-fold.

To produce the adjustment series of new lathes (the Srednevolzhskiy Machine Tool Plant of Kuybyshev, the Moscow Krasnyy proletariy Machine Tool Plant imeni A. I. Yefremov) and the test model of a lathe (the Ryazan' Machine Tool Building Production Association) with small devices for numerical program control on the basis of microcomputers. At the Moscow Plant of Jig-Boring Machines to produce a high-precision jig-boring machine with a tool box and a device for numerical program control on the basis of microcomputers.

At the Voronezh Production Association for the Output of Heavy-Duty Power Presses to produce crank shears (five units) for the precision cutting of blanks; the use of the shears will provide a saving of metal of up to 10 percent and will increase the productivity of machining 1.8-fold.

At the Taganrog Plant of Forge and Press Equipment to produce an automatic twin-crank stamping machine, which ensures an increase of labor productivity by twofold.

The further increase of labor productivity is the most important condition of the successful fulfillment of the socialist obligations adopted for 1980. Taking this into account, a set of target and additional measures on the mechanization and automation of production processes, the reduction of the proportion of manual labor, the improvement of the use of working time, the increase of the skills of workers and engineering and technical personnel, the introduction of advanced know-how and others have been drawn up in the Ministry of the Machine Tool and Tool Building Industry. Of the indicated measures the main ones are cited below.

1. The introduction in production of not less than 1,000 machine tools with numerical program control, which will make it possible to release 3,000 workers and 1,380 general-purpose machine tools.

2. The early installation, adjustment and placement into operation of 14 automatic and 100 mechanized flow lines; 1,360 units of highly productive equipment (automatic machines, standard-unit and special machine tools); 697 conveyers, transporters and other materials-handling machinery; 56 mechanized warehouses.

3. The reduction of the labor-output ratio of machining by 330,000 norm-hours by using tools made from synthetic superhard materials.

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4. The early fulfillment of the five-year plan on the introduction of advanced technology, the mechanization and automation of production processes according to the main indicators by 7 October 1980.

5. The increase of the output of casting by the completely mechanized method to 998,000 tons, ingots by the method of continuous casting to 25,000 tons, casting with the use of self-hardening mixtures to 830,000 tons, ingots made from pig iron obtained in induction furnaces to 101,300 tons and the receipt as a result of this of a considerable saving of metal and other materials.

6. The introduction at the Bogotol Plant of Fitter's Installation Tools of two mechanized flow lines for the production of stamped parts with a capacity of 2,000 tons a year.

7. The assimilation at the Shilute Gidroprivod Plant and the Nikolayevskiy Pilot Plant of Lubrication Systems of the production of highly stressed parts made from aluminum allows by chill casting and injection molding, which will make it possible to save 150 tons of rolled aluminum and to reduce to ten-seventeenth the labor-output ratio of machining.

8. The introduction at the Kalinin Tsentrosvar Plant of Welded Components of a set of automated flow lines for the purpose of increasing the output of welded components in 1980 to 22,000 tons.

9. The early (by 1 December 1980) placement into industrial operation of the sectorial automated control system (consisting of 14 subsystems).

The machine tool and tool building industry in four years of the 10th Five-Year Plan increased the production volume of commodity products 1.41-fold as compared with 1975. The national economy received during this period about 455,000 machine tools, 151,000 forge and press machines, more than 1,000 automatic and semi-automatic lines for metalworking, as well as much other equipment and tools.

In the work on further expediting economic growth it is necessary to use more extensively the experience of innovators and production leaders. To assimilate it everywhere, to adopt all the best things born of the initiative of the masses means to put into effect the great internal production potential. It is necessary to develop more extensive the socialist competition, which is aimed at the increase of production efficiency and work quality, to step up the movement for a communist attitude toward labor, to inculcate in every worker, engineering and technical worker and employee a genuinely practical attitude toward his job.

Socialist competition is a proven method of achieving high production indicators. Practice has confirmed that competition is an effective lever of the increase of production, ensures high technical and economic indicators and plays a leading role in the communist education of the workers. The

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year of 1980--the year of the 110th anniversary of the birth of V. I. Lenin--should become a year of shock labor, a year of work in the Leninist way.

The consistent implementation of the economic strategy of the CPSU is inseparably connected with the increase of production efficiency and work quality. The drive for efficiency and work quality is making new demands on the management of the economy of each sector and each enterprise.

The decree of the CPSU Central Committee and the USSR Council of Ministers, "On Improving Planning and Strengthening the Influence of the Economic Mechanism on Increasing Production Efficiency and Work Quality," affords labor collectives new opportunities to seek rational methods of management and to display creative initiative. The responsibility of managers and each worker for the fulfillment of the plan assignments and the adopted socialist obligations is increasing.

In the system of measures on the improvement of the management of the socialist economy great importance is attached to the skillful use of economic levers--cost accounting, the profit, the price, the bonus. Cost accounting is a method of the planned management of production, which is aimed at the achievement of the greatest national economic results and at the increase of work efficiency and the quality of the products being produced. Cost accounting makes it possible to combine centralized planning and the creative activity of the masses, unites the interests of the state, the enterprise and each worker and promotes the quickest possible solution of social problems.

The decree of the CPSU Central Committee, "On the Further Improvement of Ideological and Political Educational Work," is of enormous importance in the matter of the communist education of the workers and the further increase of the creative activeness and consciousness of each Soviet individual. The practical implementation of this decree is the primary task of the party organizations of each enterprise and association of the sector. The duty of the managers of all levels is to improve the style and methods of work, to tighten up labor, planning and production discipline and to step up the monitoring of the fulfillment of the plan assignments and the decisions which have been made.

The workers, engineering and technical personnel and employees of the machine tool and tool building industry should apply all their knowledge and creative energy for the unconditional fulfillment of the adopted socialist obligations and the plan assignments of 1980--the year of the 110th anniversary of the birth of V. I. Lenin.

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Automated Milling Machines

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 80 pp 3-7

/Article by A. N. Bobrov and Yu. G. Perchenok: "Automated Milling Machines for the Three-Dimensional Machining of Parts"/

/Text/ The Leningrad Machine Tool Building Production Association imeni Ya. M. Sverdlov produces (according to the plans of the Leningrad Special Design Bureau of Machine Tools) a range of automated milling machines for the three-dimensional machining of parts of complex form. General-purpose and special machine tools (for machining items like press molds, propellers and so forth) are produced.

Depending on the method of setting the trajectory of the movement of the cutter with respect to the part being machined the machine tools are divided into two types: profile-milling and milling machines with numerical program control. Both types of general-purpose machine tools are produced on the basis of standardized machine blocks.

The machining of items on automated milling machines is carried out by special cylindrical or conical cutters with a spherical tip, which are produced from high-speed steel or a hard alloy. There are three methods of working complicated surfaced: the seam, contour and three-dimensional methods.

The technical characteristics of the base models of general-purpose automated milling machines (with the horizontal positioning of the spindle) are cited in the table. The following modified versions of machine tools are produced on the basis of the base models: with increased movements (vertical and horizontal); with mirror duplication; paired machine tools and so on.

The production of special five-coordinate machine tools on the basis of general-purpose three-coordinate machine tools (see the table) is envisaged for the machining of especially complicated parts (like propellers, blade wheels and so forth). In this case a unit with revolving tables is installed on the table of the base machine tool.

Descriptions of the designs of general-purpose and special automated milling machines are cited below.

Milling machine model 6B443GF3 (Figure 1) with numerical program control is produced on a common base with profile-milling machine model 6B443G and consists of a fixed stand and a moving horizontal table. The base of the stand is rigidly connected to the bed. The main working units of the machine tool move in the horizontal (the table with the item being machined), vertical (the cross piece with the headstock seated on it) and axial (the headstock) directions.

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Parameters	Model of machine tool			
	6B443	6B444	6A445	6446
Dimensions (length X width) of the surface of the table, mm	1250 X 630	2000 X 1000	3150 X 1600	5000 X 2500
Greatest vertical displacement of the headstock, mm	560	800	1250	1800
Greatest horizontal displacement of the table or stand, mm	1000	1400	2240	4000
Greatest axial displacement of the spindle, mm	320	500	630	800
Cone of the spindle according to All-Union State Standard 836-72	50	50	55	60
Additional axial movement of the tail spindle, mm (not less than)	160	200	200	250
Diameter of the journal of the spindle in the forward mounting, mm	80	100	130	170
Rating of the main drive, kW	5.5	7.5	10	17
Greatest torque on the spindle, N·m	600	1000	2000	3000
Rate of rotation of the spindle, rpm	31.5-2500	25-2000	35.5-1800	31.5-1600
Speed of working feeds, mm/min	6-1000	6-1000	6-1000	6-1000
Speed of adjustment movements, mm/min	4000	4000	3000	3000
Weight of machine tool, tons	13	22	35	75

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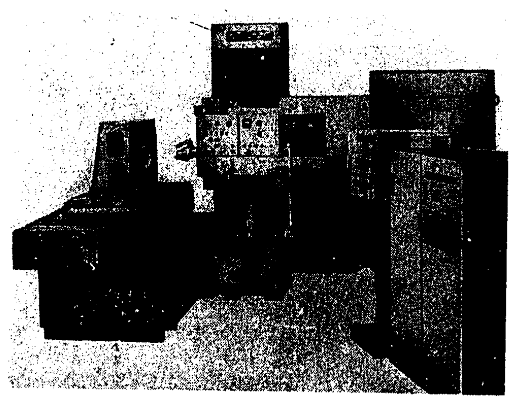

Figure 1. Milling Machine Model 6B443GF3 With Numerical Program Control

The circulatory lubrication of the combined (sliding and rolling) guides is accomplished centrally. Telescopic devices are envisaged to prevent cuttings and cutting fluid from getting into the guides. The drive of the main movement is derived from an AC motor. The spindle is mounted on precision roller bearings in the tail spindle and has adjustable movement, which is accomplished manually.

The electromechanical drives of the feeds of the working units are fitted with quick-response electric motors like the GTG-1, reducers with the minimal clearances and ball-type worm gears. Machine tools with drives of the feeds from high-torque motors, which are connected directly to the lead screws through special clutches, are also produced. The balancing of the vertically moving masses (the cross pieces with the headstock) is accomplished hydraulically. A special hydraulic clutch has been installed on the lower end of the vertical lead screw in order to prevent the spontaneous downward movement of the cross piece with the headstock seated on it (when the machine tool is shut off and in emergency situations).

The machine tool is equipped with a system for cooling the cutting tool, a conveyer for removing the cuttings and cutting fluid, as well as a device which protects the cutting tool from overloads.

The system of numerical program control like the N552 is equipped with digital display. Inductosins are used as sensors of feedback on the position. Control of the machine tool is carried out from a panel located on the headstock or from the panel of numerical program control.

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Profile-milling machine model 6B444 (Figure 2 /photograph not reproduced/) is designed for profiling various items of complicated form, including mirror-symmetrical items. The machine tool has an original portal arrangement with two vertically positions tables. The stand of the machine tool is set in a base, which is fixed rigidly to the bed. The stand of the master form, which in the upper portion is connected by a beam with the main stand, is mounted on the upper surface of the bed. Thus, the chassis parts form a portal, owing to which the machine tool acquires additional rigidity.

The main operating units of the machine tool move in the horizontal (the table with the article being machined and the table of the master form), vertical (the cross piece with the headstock seated on it) and the axial (the headstock) directions. The tables of the article and the master form can move together (in direct duplication) or toward each other (in mirror duplication). The movement of the table of the master form is accomplished by means of a special rack mechanism.

The profiling instrument is fastened in a special chuck, which is mounted on the headstock, and can be moved in the horizontal, vertical and axial directions.

The roller guides of all the operating units of the machine tool, which are fitted with hardened cover plates, are protected from cuttings and cutting fluid by telescopic devices. The headstock, the drives of the feeds, the balancing mechanism and the accessory mechanisms are analogous in design to the corresponding units of machine tool model 6B443GF3.

The control of the machine tool is carried out from a special work bridge, which is equipped with a table, a tool stand, a stand for blueprints, a swivel seat and a partition.

Profile-milling machine model 6A445 (see the first page of the cover /photograph not reproduced/) is arranged so that during the machining the headstock with the tool moves, while the article remains fixed. The main operating units of the machine tool move in the horizontal (the sled with the stand), vertical (the cross piece with the headstock seated on it) and axial (the headstock) directions. The profiling instrument is mounted on the headstock. The article and the master form are attached to the stands, which have been mounted to the table which is rigidly attached to the seat. The stands have joint adjustable movements in the horizontal and axial directions (moreover, the top stands can be moved with reference to the bottom stands); all the movements of the stands are mechanized.

The machine tool is equipped with guides with hydrostatic lubrication (for the movement of the sled of the stand) and with sliding guides (for the movement of the cross piece and the headstock). The drive of the main movement is derived from an AC motor. In order to move the headstock and the cross piece a ball-type worm gear is used as the output unit of the feed gear, while in order to move the sled of the stand a special screw-rack sliding gear with a choice of clearance is used.

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Differential reduction gears are used in the feed drives of the cross piece and the sled of the stand. The accelerated movement of these units is accomplished from an induction motor, while the working feed is accomplished from a quick-response DC motor like the PGT-2. The machine tool is equipped with an automatic profiling system, a conveyer for the removal of cuttings and cutting fluid, as well as other accessories.

Profile-milling machine model 6446 (Figure 3 /photograph not reproduced/) has an original arrangement (the horizontal positioning of the spindle and the vertical positioning of the profiling instrument), which considerably simplifies the mounting of the article and the master form and ensures the machining of mirror symmetrical (with respect to the master form) parts.

The main operating units of the machine tool move in the horizontal (the sled with the stand), vertical (the cross piece with the headstock seated on it) and axial (the headstock) directions.

The profiling instrument is fastened in a special chuck on the carrier and has horizontal and vertical movement. The vertical movement of the headstock is coordinated (by a flexible connector) with the horizontal movement of the carrier. The flexible connector is made in the form of a steel belt, which derives motion from the cross piece and transfers it to the carrier. A mode of direct or mirror duplication is realized depending on which run of the belt (the top or bottom) the carrier is connected to.

The axial displacement of the headstock kinematically is rigidly connected with the vertical displacement of the duplicating instrument, which also has additional manual adjustable displacements which are necessary for the adjustment of its position with respect to the master form before the start of the machining. The master form is mounted on a table which is situated on the seat. The article is attached to stands which have mechanized adjustable movements.

The main drive, the feed gears and the accessories are analogous to the design of the corresponding units of machine tool model 6A445.

The control of the machine tool is carried out from a special elevator bridge, which has independent vertical movement, which considerably facilitates the handling of the machine tool and improves the field of view of the work zone.

Special profile-milling machine model LR266 (Figure 4 /photograph not reproduced/) is designed for the machining of press molds of large tires according to a master form which reproduces one (repetitive) sector of the press mold; direct and mirror duplication are possible. The adjustment of the master mold to the initial position (at the start of the cycle of machining of the next part of the profile of the press mold) is carried out automatically.

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The machine tool is made from two separate parts, which are mounted on a single seat. The article being machined is attached to the faceplate, while the master form is attached to the rotating section located above the article. The faceplate and the section have a kinematic connector and derive motion from a common drive. The headstock is mounted on a cross sled and has two mutually perpendicular movements: axial and cross. The angular orientation of the cutter with respect to the profile being machined is ensured by turning the sled about the guides of the curved stand. The duplicating instrument is mounted on the headstock. The control of the machine tool is carried out from the work bridge, which is kept from turning by a pantographic device.

Specifications

Diameter of the faceplate, mm.	3200
Greatest displacement (axial and cross) of the headstock, mm . . .	1200
Greatest angle of rotation of the headstock, degrees	90
Rating of the main drive, kW	6.1/7.3
Rate of rotation of the spindle, rpm	125-1600
Speed of working feed (axial and cross), mm/min.	12.5-500
Speed of rapid adjustment movements (axial and cross), mm/min. . .	2000
Dimensions of machine tool (length X width X height), mm . . .	8000 X 7900 X 4750
Weight, tons	60

Special profile-milling machine model LR323 (Figure 5 /photograph not reproduced/) is installed on the table of machine tool model 6A445 and is designed for the machining of the parts of the press molds of end windings of hydraulic generators. The machine tool has two faceplates (for the article and the master form), which turn together around the vertical axis and synchronously around the horizontal axes. A special mechanism with the automatic choice of clearances is used for the kinematic connection of the faceplates. The reading of the angles of rotation is made by round inductosins in combination with a digital display.

The machine tool makes it possible to machine an article by the productive contour method of duplication (instead of the seam method), which also increases the precision of the milling. In the process of machining the part the moving units of the machine tool are made fast by hydromechanical clamps. The control of the machine tool is carried out by means of a detached panel.

Specifications

Diameter of the faceplate (of the article and the master form), mm.	1200
Distance from the horizontal axis of the faceplate of the article to the table, mm.	1000
Distance between the horizontal axes of the faceplates of the article and the master form, mm	1320
Angle of rotation of the faceplates around the vertical axis, degrees	+90 to -30

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Specifications (continued)

Rate of rotation of the faceplates around the vertical and horizontal axes, rpm.	0.0005-2.5
Dimensions of machine tool (length X width X height), mm. .	2100 X 1600 X 3000
Weight, kg.	9000

Special milling machine model LR336F3 (Figure 6) with numerical program control is intended for the machining of articles of complicated form (cams, propellers, power wheels and so forth) and is designed on the basis of series-produced machine tool model 6B444F3. A special unit, which ensures the rotation of the stock of the article with respect to the vertical axis and the faceplate with the article with respect to the horizontal axis, is mounted on the three-coordinate table of machine tool model 6B444F3. Reduction gears with devices for the selection of clearances and the creation of preliminary tension are used in the rotation gears. The machine tool is equipped with a system of numerical program control like the N552M. Linear and round inductosins are used as sensors of the feedback on the position.

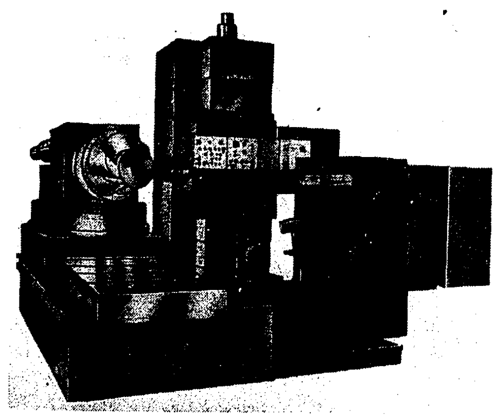

Figure 6. Special Milling Machine Model LR336F3 With Numerical Program Control

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Specifications

Distance from the horizontal axis of the faceplate to the table, mm.	800
Angle of rotation of the head of the article, degrees.	45-135
Rate of rotation of the table, rpm	0.0016-1.25
Rate of rotation of the head of the article, rpm	0.00125-0.4
Greatest diameter of the part being machined, mm	1000
Greatest weight of the part being machined, kg	1000

Design of the Main Units. When machining items on automated milling machines the duty of the drive of the main motion changes relatively infrequently, which makes it possible to use AC electric motors. The gear boxes are built into the housing of the headstock; the hardness of the working surface of the teeth of the gears is HRC 45-60. The adjustment of the spur gears, which is made according to a special system /1/, increases the durability of the gears of the drives of the main movement and the feeds. A flexible nonlinear clutch /2/ (which protects the kinematic circuit against overloads) and an electromagnetic friction clutch (for slowing) are mounted on the shaft of the motor of the drive of the main movement. The lubrication of the gear box is accomplished centrally from a pumping station.

The spindle units of the machine tools are made (as a rule) to be twin-supporting, on roller bearings. The taper of the spindle (7 : 24) facilitates the changing of the tool and makes it possible to use its mechanized clamp. Normally closed clamps with disk springs and hydraulic drive for the release of the tool /3/ are mounted on machine tools of models 6B443 and 6B444. The spindle is mounted in the tail spindle, which has manual adjustable movement.

Various types of guides are used for moving the units. The combined guides (Figure 7) of the table of machine tool model 6B443GF3 are rectangular, closed, with pretension. The weight of the unit with the part and the vertical component of the cutting force are absorbed by the roller bearings. The pretension of the roller bearings is accomplished by adjustment devices with wedges. The horizontal components of the cutting force and the tilting moments are absorbed by the sliding guides.

Clamps, which clamp the table to the base surface of the mounted guides, are used for the selection of the clearances in the sliding guides during finishing. During rough finishing the clearances are not selected and the unit can be moved to the point of contact with the wedges. The latter are mounted with a clearance not exceeding 0.03 mm. In Figure 7 the wedges are located in the area of the right-hand mounted guide, one of the surfaces of which is the base surface. A filled fluoroplast of brand F4K15M5 in combination with hardened steel is used as an antifriction material.

Hydrostatic guides, which are equipped with an automatic lubrication control system /4/, are used for moving units of great weight. The design of the hydrostatic guides of the table of machine tool model 6A445 is described in work /5/. The guides, as a rule, are protected from cuttings and cutting fluid by telescopic devices.

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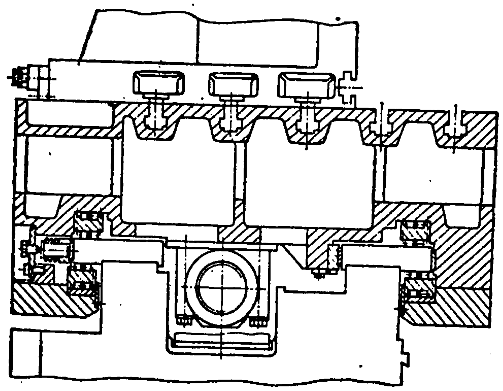

Figure 7. Combined Guides of the Table of Milling Machine Model 6B443GF3

The feed drives are electromechanical. Ball-type worm gears (for movement of up to 2 m), as well as rack or screw-rack gears (for greater movements) are used as the output units for movements of the units. The kinematic diagrams of the feed drives are made, as a rule, with the compulsory selection of the clearances [5 and 6], the standard diagram of which is cited in Figure 8. This diagram is used in the drives of the advances of the units, which are achieved by means of rack gears, and in the drive of rotation.

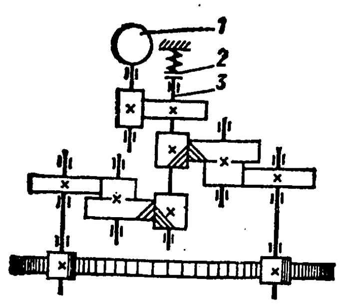

Figure 8. Standard Diagram of the Choice of Clearances in the Kinematic Circuit of the Feed Drive

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The power contact of the kinematic circuit is made by the axial displacement of the shaft 3 of the reduction gear under the influence of the spring 2 (or hydraulic cylinder). Pretension is created in the circuit owing to the spiral gears which are rigidly fixed for the shaft 3 (with the same angles of inclination of the opposite direction). The diagram from work /7/ is used if it is necessary to choose the clearance in the drive which comes directly from the motor 1. Some other means of selecting the clearances are also described in work /5/.

The lead screws are fitted with sets of thrust bearings, which absorb the axial forces and are mounted, as a rule, on two sides (to increase the rigidity of the feed drive).

Automatic Control Systems. The profile-milling machines are equipped with automatic duplicating systems /8/, which operate in the contour mode (with an unlimited angle of duplication and compensation of the influence of the actual angle) and the seam mode (with an angle of duplication of $\pm 90^{\circ}$, without compensation). The tracing block is constructed according to the principle of phase control; a proportionate-integral regulator is used to increase the precision of duplication. The feed drive is thyristor, servo and regulated. Motors of series PGT with an unslotted armature are used as the servo motors, tachogenerators built into these motors are used as sensors of feedback on the speed. The drive can also operate with high-torque motors.

The experience of using machine tools, which are equipped with the described duplicating systems, has shown the simplicity and convenience of the construction of the systems, as well as their great stability and reliability. The precision of the tracing is characterized by the following indicators /8/: the steady-state error with a tracing speed of not more than 250 mm/min is ± 0.03 mm in the seam mode and ± 0.02 mm in the contour mode; the transient dynamic error during a "point-blank approach" on a laboratory bench is 0.08 mm (the tracing speed is 1,000 mm/min). The real value of the dynamic error depends on the parameters of the servo motors of the machine tool equipped with this system /5/.

Milling machines are equipped with systems of numerical program control like the N552. Inductosins mounted directly on the servo device are used as the sensors of feedback on the position. The program is recorded on a standard perforated tape (25.4 mm wide) in the ISO coding system and is fed in from the panel of the system of numerical program control. The discreteness of the assignment of information is 0.01 mm.

Without changing the control program, it is possible to perform the following operations on the machine tools: mirror machining (male and female dies); production on a reduced scale (1 : 2; 1 : 1.5; 1 : 10); the mounting of a tool of a different length and diameter; the change of the allowance for the next machining. The system of numerical program control is equipped with a digital display.

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The Precision of Machining. Since automated milling machines are intended for the machining of complicated surfaces, the precision of the reproduction of the form, which is characterized by the sum of the maximum deviations of the real surface of the part from the ideal surface, which is identical to the set shape, is decisive for them. The precision of machine tools changes subject to the type and mode of machining, the dimensions and shape of the item and the rate of feeding.

The extreme indicators of precision are conventionally called the static and dynamic error /5/. The static error (the steady-state error with the minimum rate of feeding and a large radius of the equidistance to the set shape) characterizes the maximum attainable precision of the machine tool. The dynamic error (the transient dynamic error with the maximum rate of feeding and the greatest d.:ty, which corresponds to the circumvention of the internal right angle) characterizes the guaranteed precision with the maximum productivity of the machine tool. For any other conditions the error of the machining is within the indicated boundaries.

The static precision of profile-milling machines is ±(0.02-0.10) mm, and with the contour method of machining it is, as a rule, higher than with the seam method. The dynamic precision of profile-milling machines is governed by the parameters of the mechanisms of the machine tool and is, for example, for machine tools of models 6B443F and 6B444 0.4-0.5 mm with a tracing speed of 1,000 mm/min. In mirror duplication the precision of machining decreases. The static precision of milling machines with numerical program control is ±(0.02-0.05) mm, while the dynamic precision does not exceed 0.1 mm. From the cited data it is evident that the static precision in machining on profile-milling machines and milling machines with numerical program control is approximately identical, while the dynamic precision is considerably higher in machining on milling machines with numerical program control.

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Precision Machining on Lathes

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 80 pp 11-12

/Article by Zh. N. Kadyrov, E. L. Zhukov and K. P. Dolgov: "Increasing the Precision of Machining on Lathes With Numerical Program Control"/

/Text/ Experiments conducted at the Special Design Bureau of Machine Tools (Leningrad) established that when working with a lathe of model 16K20F3 with the lubrication of the guides of the saddle with industrial oil the precision of the production of parts is within the range of quality 9-10. A special device (Figure 1) was developed for increasing (as required) the precision of machining by dimensional deviation control.

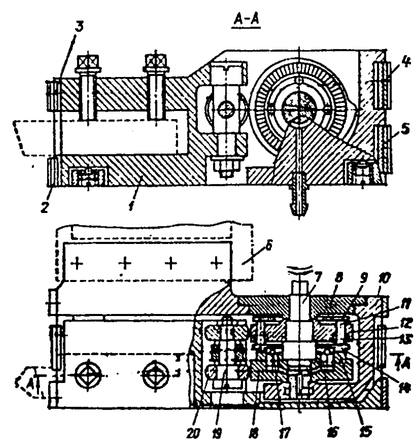

Figure 1. Special Device for the Adaptation of Tools

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The tool holder 1 by means of flat springs 2, 3, 4 and 5, which are mounted on its facing surfaces, is attached to the housing 10 of the device. A double-arm lever 19 with the rollers 20 located at its ends is mounted on the tool holder. This lever forms with the cams 18 and 12 (they have a different characteristic slope and direction of the contours) a differential cam gear.

Cam 18 is rigidly attached to drive shaft 7, while cam 12 is connected with it by means of a controllable clutch. Half-coupling 15 is realized on the face of cam 18. Plungers 11, which are connected with half-coupling 14 and brake disk 9, are fitted in the openings of cam 12. Springs 13 are positioned on the plungers 11. The pistons 16 of the pneumatic drive of the clutch are mounted in the openings of cam 18. These pistons make contact with the half-coupling 14 through ball bearings 17. The described device is mounted in the tool holder 6 of the machine tool instead of a cutter.

During adjustment rough displacements (over a wide range) of the tool holder 1 with respect to the housing 10 of the device are made by rotating the cam 18. Here the cam 12 is checked by the brake disk 9, for which compressed air is fed through a connecting pipe into the working chamber of the pneumatic drive of the clutch. The pistons 16 act on the half-coupling 14 through the ball bearings, disengaging it from the half-coupling 15 and pressing the brake disk 9 against the facing surface of the cover 8.

When the feeding of compressed air is halted, under the influence of the springs 13, the brake disk loses contact with the face of the cover 8, while the half-coupling 18 couples with the half-coupling 15. The simultaneous rotation of cams 18 and 12 causes displacements of the rollers 20 (which are different in magnitude and direction). Here precision displacements, which are determined by the displacements of the rollers 20, are imparted to the tool holder 1 through the double-arm lever 19. The drive shaft 7 is turned by means of a step-by-step motor.

The differential cam gear has ranges of displacements of 4 mm, which are sufficient to eliminate the inaccuracies in bringing the cutter up to the required set-up size (rough displacements, a discreteness of 0.005 mm) and to further offset the initial errors of machining (fine displacements, a discreteness of 0.0025 mm). This makes it possible to increase the precision of machining to quality 7-8. The making of the flat springs 2-5 different in rigidity increased the resistance of the device to vibration, as a result of which the roughness of the surface being machined decreased.

Such a device is used for machine tools with a single-position cutter head. For machine tools with multiposition cutter heads it is advisable to carry out the adjustment of the cutter by moving the carrier, if in this case sufficient precision and stability of the bringing to the required position are ensured. This is achieved by the reduction of the friction in the guides, for example, with the use of shock-proof plastics which are based

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on fluoroplast[1] as the material of the mounted guides. It has been established that filled fluoroplast F4K15M5 has the most favorable friction characteristics. Thus, its coefficient of friction subject to the slip velocity almost does not change, while when working in combination with pig iron the coefficients of the friction of starting and movement are practically the same and do not exceed 0.08-0.09.

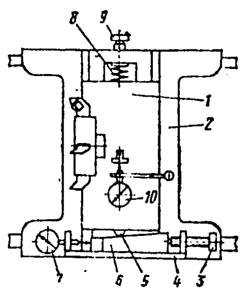

Figure 2. Stand for Determining the Precision of the Displacement of the Carrier

The precision of the displacement of the carrier with the mounted guided made from filled fluoroplast F4K15M5 was studied on a stand (Figure 2), which was assembled on the basis of the saddle of the machine tool. The carrier 1, which under the action of the spring 8 makes contact with the slanted slide 6 through the point bearing 5, was displaced by this slide by means of the screw 3. A measuring head 7 was used for the precise recording of the displacement of the slide. The slanted slide with the screw and the measuring head were mounted on a plate 4, which was rigidly attached to the saddle 2 of the machine tool. The force of the spring 8 was regulated by a screw 9. During the study they assigned various values of the displacements (from 0.01 to 2 mm) of the carrier of the machine tool and for each value repeated the experiment 10 times. The actual positions of the carrier when it reached the checking point were recorded according to the reading of the spring measuring head 10 (the scale division is 0.2 μm).

The deviations x of the actual positions of the carrier of the machine tool from the set positions were regarded as random values. The precision of the adjustment was estimated by the cumulative deviation A (which was calculated according to the algebraic difference of the extreme arithmetic means $\overline{x}$) and

1. K. P. Dolgov, M. K. Varlamov, "Metodicheskiye rekomendatsii po primeneniyu ftorlona v kachestve nakladnykh napravlyayushchikh" /Methods Recommendations on the Use of Fluorlon as Mounted Guides/, Leningrad, Special Design Bureau of Machine Tools, 1977, 28 pages.

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the standard deviation σ. The plots of the precision of the adjustment of the carrier of the machine tool with mounted guides made from filled fluoroplast F4K15M5 are cited in Figure 3. As is evident, the use of the mounted guides makes it possible owing to the increase of the precision of adjustment of the tool to produce parts with a precision quality of 7-8. Here the smoothness of the displacement of the carrier and the reduction of the force of the feed drive are noted.

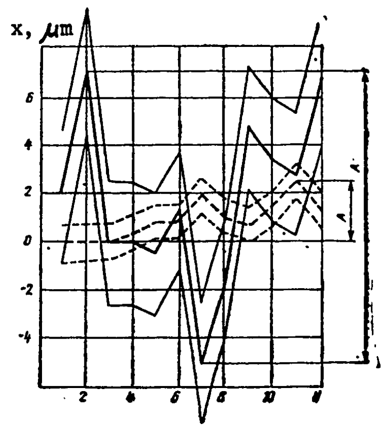

Figure 3. Precision of the Adjustment of the Carrier of a Machine Tool With Conventional (Solid Line) and Mounted Guides Made From Filled Fluoroplast F4K15M5 (Broken Line); N is the number of the checking point; the middle lines are the change of the values of x, the outside lines are the boundaries of the intervals $\pm 3\sigma$.

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Simplified Numerical Programming

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 80 pp 12-13

/Article by Ya. G. Gol'din, A. Yu. Mal'chik and L. N. Faynshteyn: "A Simplified Device for the Numerical Control of a Machine Tool According to Fixed Programs"/

/Text/ The device being described is designed for implementing fixed cycles of the operation of a machine tool, which contain as components of the path of the tool segments of lines, arcs of circumferences and other curves. The minimum amount of variable numerical information is required for setting these cycles. The following can serve as examples of such cycles.

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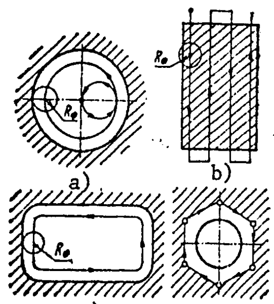

Figure 1. Examples of Cycles ($R_Ф$ is the radius of the cutter): a--the machining of a circumference by milling; b--the milling of a rectangular area; c--the milling of a rectangular bed; d--positioning for the machining of six holes.

The machining of a circumference by milling (Figure 1a); the path of the tool consists of semicircumferences of the contact and withdrawal of the cutter and the complete circumference of the working motion. One number--the radius of the equidistance to the circumference being machined--is required to set the cycle.

The machining of a rectangular area by milling (Figure 1b) with the setting of three parameters: the length of the pass, the feed per pass and the number of passes.

The machining of a rectangular bed by milling (Figure 1c). The path consists of four interlinking arcs and two pairs of segments and is set by three parameters: the radius of the equidistant arcs and the lengths of the segments.

Positioning for the machining of regularly spaced holes (Figure 1d), particularly four, six or eight mounting holes lying on one circumference, for which it is necessary to set two parameters--the radius of the circumference and the number of holes.

The threading, for which the pitch of the thread and the depth of the cutting are set.

It is advisable to use simplified devices of numerical control according to fixed programs, which implement one of the cycles, for special and specialized machine tools which are used for producing parts of a single configuration. The form of the path of the tool and its numerical characteristics are constant and are entered in a permanent memory (ПЗУ) during its production. Only the correction for the size of the tool is variable information.

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The devices in question can also be used for general-purpose machine tools as autonomous devices which implement a set of cycles. Such devices increase the productivity of the machine tool (automatic positioning for the machining of regularly spaced holes, the milling of beds and areas), make it possible, moreover, to reduce the expenditures and to shorten the period of preproduction (for example, owing to the reduction of the nomenclature of tool chucks when replacing the boring of holes by milling), as well as to simplify the design and to reduce the labor-output ratio of the production of the machine tool.

The simplified devices, first of all, are characterized by a small amount of input (variable) data and a limited number of modes of operation; they control, as a rule, no more than two coordinates simultaneously. This makes it possible to discard all types of digital display and input devices with a program carrier and to reduce the control panel. The mentioned circumstances make it possible to design the simplified device (including the power supply system) in the form of a block with a volume of up to 25 dm^3, by using only widespread electronic components. Such a block can be installed in the electrical box of the machine tool.

In a number of instances the simplified device of numerical program control proves to be preferable to the operational and productive systems[1] of program control. First, such a device does not require an increase of the area taken up by the electrical equipment of the machine tool. Second, the standby block of the simplified device can be included in the set of the delivery of the machine tool, which considerably facilitates repair in case of the breakdown of the device. Thus, the simplified device in practice does not worsen the maintainability of the machine tool (as compared with a machine tool without numerical program control) and does not increase the idle time during repairs. Finally, the cost of the simplified device is considerably less than for any traditional device of numerical program control.

A simplifed device of numerical program control for milling machines, which are intended for the machining of the parts of a tractor according to the outer contour, was designed at the Special Design Bureau of Machine Tools. These machine tools can be incorporated in an automatic line.

The device is a part of the electrical equipment of the machine tool. It operates according to a rigid program which specifies the preliminary calculations, which are connected with the consideration of the real radius of the cutter, the formation of all the segments of the path of the center of the cutter and the control of the rate of its movement during machining. The manual control of the movements of the units of the machine tool is also carried out by means of this device.

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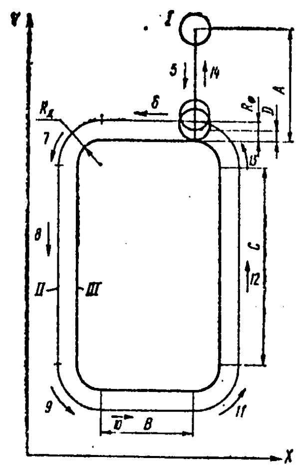

Figure 2. Diagram of the Machining of an Item: I--initial position of the cutter; II--the path of its center; III--the contour being machined; 5-14--the components of the program; A--the distance from the contour of the item to the center of the cutter in the initial position; B, C, $R_{\text{д}}$--the dimensions of the item; D--the rated allowance.

The contour of the part being machined and the path of movement of the cutter, which is broken down into segments, are shown in Figure 2. The rigid program consists of 14 components (see the table). The dimensions A, B, C and $R_{\text{д}}$ are constant for the part being machined and its positioning on the machine tool and are entered in the permanent memory of the device. The dimension D, which characterizes the allowance for machining, is also contained in the permanent memory, but can be recalled for a batch of blanks over the range of 9-20 mm (with a spacing of 1.28 mm).

The device ensures four different settings of the contour speed: on the linear and curved segments of the equidistance, during the cutting in, as well as in the approach to the item (and return to the initial position). The operational adjustment of the contour speed from the panel of the machine tool is also possible.

The structural diagram of the device (Figure 3) contains the main units which are typical of the standard device of numerical program control. The processor B, which performs the preliminary calculations, the linear and circular interpretation and transfers by components of the program, is central in the structure. The arithmetic unit АУ along with the sources of data (ОЗУ1, ОЗУ2, ПЗУ and the input switch $R_{\text{ф}}$) performs the algebraic summation in binary code sequentially by tetrads.

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Component of program	Purpose of the component of the program
1	Clearing of the memory
2	Conversion of the value of the radius $R_Ф$ from binary-decimal code into binary code
3	Calculation of the radius of the equidistance of the curved segments $R_Ф + R_Д$
4	Calculation of the distance from the tool to the item $A - R_Ф$
5	Displacement in the negative direction of the Y axis by the distance $A - R_Ф$. Change in the speed at the distance D from the item
6	Displacement in the negative direction of the X axis by the distance B
7	Displacement along the arc in the second quadrant
8	Displacement in the negative direction of the Y axis by the distance C
9	Displacement along the arc in the third quadrant
10	Displacement in the positive direction of the X axis by the distance B
11	Displacement along the arc in the fourth quadrant
12	Displacement in the positive direction of the Y axis by the distance C
13	Displacement along the arc in the first quadrant
14	Return to the initial position by movement in the positive direction of the Y axis

Note: See the dimensions $R_Д$, A, D, B, C in Figure 2.

To represent the number with a sign 16 digits are used, which with a discreteness of 0.01 mm makes it possible to obtain the radius of the arc and the length of the segment of up to 320 mm. The time of an operation on one tetrad is 2 μs, which ensures a rate of the operations on the numbers of 125 kHz and an output frequency of the unary code of displacements of up to 30 kHz. In the device being described in conformity with the technological requirements the output frequency does not exceed 3 kHz.

Before the start of the movement preliminary operations on the transformation of the code and preliminary calculations are performed in components 1-4 of the program (see the table). The value of the radius of the cutter in binary-decimal code is transmitted from the switches via the block of optrons and relays БОР to the input of the multiplexer МП and is transformed into a value in binary code. The transformation is carried out according to a standard algorithm, which contains the tenfold summation of the function of the preceding decades of the code of $R_Ф$ and the addition of the result with the value of the subsequent decade. The total time of the preliminary operations is not more than 1 ms.

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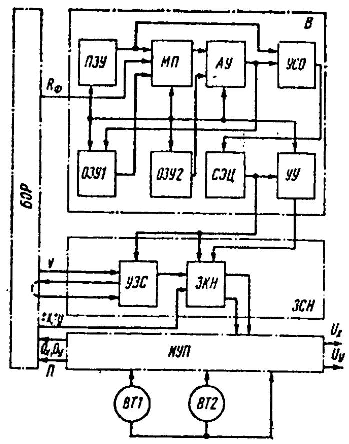

Figure 3. Structural Diagram of the Device: БОР--block of optrons and relays; ЗСН--setting of the speed and direction of displacements; ИУП--unit of the measurement and control of the drive; ПЗУ--permanent memory; МП--multiplexer; УСО--device for comparing the operands; ОЗУ1 and ОЗУ2--main memories; СЭЦ--recorder of the components of the program; УУ--control unit; УЗС--speed setting device; ЗКН--device for setting the coordinate and the direction; ВТ1 and ВТ2--rotating transformers; R_ϕ--radius of cutter; v--contour speed; ±x and ±y--commands for displacements; 0_x and 0_y--signals on the locating of the cutter in the initial position; U_x and U_y--voltage of the control of the drive.

With a displacement along the coordinate axes in components 6 and 8 of the program the value of the actual coordinate is stored in ОЗУ2 until it coincides with the dimension requested from the ПЗУ. Similar displacements in components 5, 10 and 12 are made until the cumulative value returns to zero. The last displacement (component 14) is accomplished in the mode of the return to the initial position, which is recorded by the sign "0 step" after the tripping of the terminal switch of the selection of the zero step.

For the circular interpolation in components 7, 9, 11 and 13 of the program the method of the evaluation function is employed with the use of the functions $F_{i+1} = F_i + x_i + 1$ for a step along the X axis and $F_{i+1} = F_i - y_i$ for a step along the Y axis, where F_i and F_{i+1} are the values of the evaluation functions before and after the step, and $F_0 = 0$; x_i and y_i are the values of the actual coordinates with respect to the center of the arc. The values of F_i are contained in ОЗУ1, while those of x_i and y_i are contained in ОЗУ2. The achievement of a zero value of the diminishing coordinate is an indication of the completion of the curved segment.

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The identification of the coincidences with the constants or with zero is accomplished in the device for comparing the operands (УСО) and leads to the switching of the recorder of the components of the program. The control unit of the processor (УУ) organizes the performance of the operation by tetrads, controls the selection of the numbers from the ОЗУ and ПЗУ and the setting of the axis and direction of displacement in conformity with the number of the component of the program.

ОЗУ1 and ОЗУ2 are each made on the basis of a K155PU2 integrated circuit. The two lower-order digits of the address of the ОЗУ are used for the selection of the tetrad, while the two higher-order digits are used for the selection of the number. The rate of movement during manual control or the adjustment of the speed during the running of the cycle is set by the magnitude of the voltage coming from the control panel of the machine tool.

The speed setting device (УЗС) carries out the transformation of the magnitude of this voltage into the frequency of the pulses in conformity with the component of the program, ensuring the uniformity of the speed on the curved segments. The device for setting the coordinate and the direction (ЗКН) forms the unary codes of displacement on the commands ±x, ±y from the panel in the case of manual control and on the commands of the processor when running the cycle.

The unit of the measurement and control of the drive (ИУП) carries out the power supply of the rotating transformers, which perform the functions of sensors of the position of the units of the machine tool, forms (on the signals of the sensors and according to the assignment of displacement) the voltages U_x and U_y of the control of the drive, the signals O_x and O_y on the locating of the units in the initial position, as well as the signal П on the exceeding of the permissible error. This device has a universal structure; the sensors are used in the phase mode with the maintenance of a direct voltage.

The block of optrons and relays ensures a high noise immunity of the device of numerical program control as a result of the separation of the integrated circuits by galvanization with all the peripheral units (the units for seting Rф and controlling the machine tool, the sensors of the position, the feed drives and the components of the automatic electrical equipment).

Specifications

Number of controllable coordinates.	2
Discreteness of the setting of dimensions, mm	0.01
Maximum linear displacement and maximum radius of arc, mm	320
Limits of speed regulation, mm/min.	5-1000
Maximum assignable radius of the cutter, mm	99.99
Gear ratio from the working unit to the sensor, mm/revolution . . .	20
Dimension of device, including power pack (length X width X height), mm.	285 X 320 X 235
Rated input, W.	35

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Microprocessor Feed Drive

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 80 pp 18-20

/Article by V. L. Sosonkin and Yu. S. Malyuga: "A Microprocessor Feed Drive for Machine Tools With Numerical Program Control"/

/Text/ The use of a microprocessor in the control system of the feed servodrive makes it possible to increase the reliability and quality of the operation of the machine tool, to improve the dynamic properties of the drive, to obtain additional information on the inaccuracy of the shape (by calculations with allowance made for the actual errors in conjunction with the operating drives) and others.

We studied the microprocessor electrohydraulic control system of the feed servodrive for machine tools with numerical program control. The features of the developed system (Figure 1) are the lack of electronic devices of analogous functioning; the control of the positioning and speed from one pulse photoelectric sensor of feedback on the position (the frequency of the pulses of the sensor characterize the speed, while each individual pulse characterizes the displacement /1/); the use of a single-stage servo control unit (which was built on the basis of a standard E32G18 unitized step-by-step drive), which receives discrete control signals.

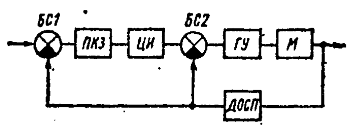

Figure 1. Structure of the Control System of the Microprocessor Servodrive: БС1 and БС2--comparison blocks; ПКЗ--sequential correction unit; ЦИ--digital integrator; ГУ--servo control unit; М--motor; ДОСП--sensor of feedback on the position.

Let us assume that both step-by-step motors in the single-step servo control unit (Figure 2) rotate in the same direction. The right-hand step-by-step motor through the screw gauge nut displaces the central rod and the slide valve distributor in the axial direction. The left-hand step-by-step motor rotates the central rod and through the screw of the screw gauge displaces it along with the slide valve distributor in the opposite direction. From this it follows that program action can be applied to one step-by-step motor of the servo control unit, while action through the feedback channel can be applied to the other.

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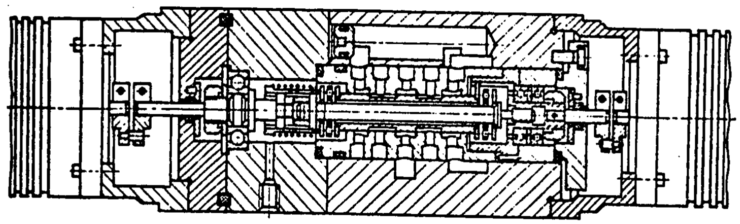

Figure 2. Design of the Single-Step Servo Control Unit, Which Is Built on the Basis of the E32G18 Unitized Step-by-Step Drive

In the structural diagram (see Figure 1) the comparison block БС1 and the sequential correction unit ПК3 are realized by software, while the digital integrator ЦИ, which forms a signal proportionate to the set speed, belongs to the hardware. This made it possible to organize the operation of БС1 in the mode of a constant carrier frequency: initially within each period the relative code increments of the signals of the program and the feedback are compared, then computation operations in conformity with the correction algorithm are performed on the result of the comparison and, finally, a multidigit code enters the input of the ЦИ, which controls the contour of speed control, which is locked in comparison block БС2.

An Elektronika NTs-03 microcomputer was used for modeling БС1 and П3К; it was regarded as the basis for building the processor of the device of numerical program control, which can solve problems of controlling the drive. Such an approach does not rule out the use of a special microprocessor, which operates in conformity with the adjusted algorithm in the servodrive.

The blocks of the microcomputer (Figure 3a) include: a 16-digit processor ПР (it has eight levels of priority of interrupt, high speed in the performance of operations of addition like "register-register" with a "short" addressing of not less than 100,000 operations/second and in the transmission of the manipulated variable with a "short" addressing of the storage cells of not less than 70,000 operations/second, a capacity of the main memory of 8K words); an arbitrator-timer AT (it carries out the distribution of the signals of the external unified main circuit ВУМ and the main data transmission circuits МПИ of the microcomputer by levels of priority); an adapter of the main circuits АМ (it realizes the logical connective and the electrical conformity of the levels of the signals of the microcomputer and the peripheral units). The interaction between all the blocks, as well as between the microcomputer and the peripheral units is asynchronous; it is governed by the sequence of the control signals: ЗП ("record"), ВДЩ ("master"), ВДМ ("dependent") and others. In all instances the signal of the receiver appears in response to the signal of the source, while the signal of the source is released in response to the signal of the receiver.

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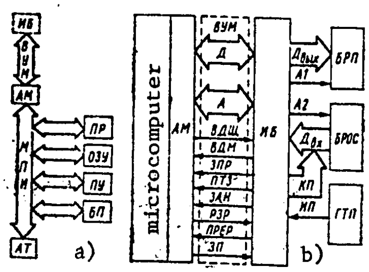

Figure 3. Structure of the Control Microcomputer (a) and the Connections of the Interface Block ИБ With the Microcomputer and the Servodrive (b): ПР--processor; ОЗУ--main memory; ПУ--control console; БП--power supply unit; АТ--arbitrator-timer; МПИ--main data transmission circuit; АМ--adapter of main circuits; ВУМ--external unified main circuit; А--address line; Д--general data line; ВДШ--master signal; ВДМ--dependent signal; ЗПР--inquiry; ПТЗ--confirmation of inquiry; ЗАН--busy; РЗР--permission; ПРЕР--interrupt; ЗП--record; ИП--interrupt pulse; КП--interrupt code; ГТП--interrupt timer; БРП and БРОС--buffer registers of the program and feedback; А1 and А2--address lines of БРП and БРОС; $Д_{вх}$--input data line; $Д_{вых}$--output data line.

The interface block ИБ (Figure 3b) serves as the buffer block between the microcomputer and the servodrive. In the process of operating the ВУМ is captured by the block. The capture request, which is initiated by the interrupt timer ГТП, enters the ИБ and then goes to the АТ, which transfers control to the ИБ in conformity with its level of priority (the fifth) in the sequence: the signal of the fifth level of priority on the line of ЗПР ("inquiry"); the receipt of the signal of РЗР ("permission"); the setting of the signal of ПТЗ ("confirmation of inquiry"); resetting of the signal of ЗПР; generation of the signal of ЗАН ("busy"). From the moment of the setting of the signal on the line of ЗАН the main circuit of ВУМ belongs to the ИБ (the exchange of data begins).

The process of exchanging data consists of the operations of interrupt, read (the receipt of the contents of the feedback channel) and record (the transmission of the control signal). In the interrupt operation the ИБ and ГТП are master, while the microcomputer is dependent. In the operations of the reading and recording of the data the microcomputer becomes master, while the ИБ along with the buffer registers of the program БРП and of the feedback БРОС become dependent.

Interrupt begins with the setting by the interface block of the signal of ПРЕР ("interrupt") and its transmission to the microcomputer through the input data line $Д_{вх}$. The processor records the interrupt signal in the register of the buffer of interrupts and uses it for the evaluation of the address of the start of the running of the interrupt program. Further, the

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arbitrator-timer sets the address of the register of the buffer of interrupts in the address line A, as well as the signals ЗП and ВДЩ; the processor receives the interrupt signal and forms the signal ВДМ; the ИБ resets the signal ПРЕР, while the AT resets the signals ВДЩ, ЗП and address; then the ИБ removes the signal ВДМ.

During the reading the address БРОС is set in line A (in feedback line A2) and the signal ВДЩ is set in the corresponding channel. After this the contents of БРОС are transmitted to the general data line Д, while the tag "dependent" (which БРОС is) appears in the channel of the signal ВДМ. On the signal ВДМ the microcomputer receives the data, then resets the signal ВДЩ and ceases the transmission of the address over the line A. The dependent register (БРОС) waits for the resetting of the signal ВДЩ and resets ВДМ. With this the reading of БРОС is completed.

When recording the address of БРП is transmitted to line A (output data line A1), the control code is transmitted to line Д, while the signals ЗП and ВДЩ are transmitted to the corresponding channels. The interface block receives the data from line Д, transmits it over line $Д_{вх}$ to БРП and generates the signal ВДМ. After receiving the signal, the microcomputer resets the signals ВДЩ and ЗП, as well as the address from line A, after which the ИБ removes the signal ВДМ. With this the receipt of the control signal in the БРП is completed.

It is possible to generalize the functions of the interface block: 1) the transformation of the two-way data line of ВУМ into one-way input and output lines; 2) the decoding of the address generated by the microcomputer and its transmission to the peripheral unit; 3) the organization of the interrupt process at the request of the peripheral unit; 4) the generation and receipt of the signals necessary for the exchange of data.

The equipment portion of the microprocessor servodrive is shown in Figure 4. The mode of operation at a constant carrier frequency of 500 Hz, which the ГТП generates, is a peculiarity of the main algorithm of the operation of the servodrive. Owing to this mode of operation the microcomputer has a considerable reserve of time for calculation operations and procedures of communication with the drive, and this reserve does not depend on the speed set for the drive by the program [2]. The routine pulse from the ГТП, which initiates the period of the constant carrier frequency, is a request for the interruption of the operation of the microcomputer. The processor of the microcomputer begins the implementation of the program of the running of the interruption, which contains the memory of the operating registers of the microcomputer, the evaluation and correction of the control signal and its transmission to the drive, the reading of the БРОС, in which the data on what was performed during the preceding period of displacement is stored (it is received from the accumulator, which sums the pulses of the ДОСП within the period), the formation of auxiliary control signals.

The microcomputer, after evaluating the control signal according to the program, transmits the code of this signal to the digital integrator ЦИ through

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the БРП. At the output of the ЦИ a signal is formed, which is represented by a unary code, the frequency of the pulses of which is proportionate to the code of the БРП. The coefficient of proportionality is the coefficient of the increase of the servodrive in speed.

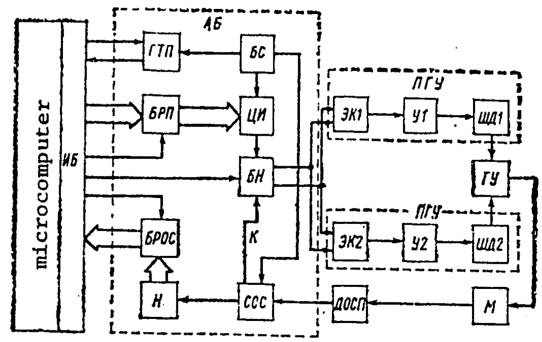

Figure 4. Structure of the Equipment Portion of the Microprocessor Servodrive: АБ--equipment block; Н--accumulator; БС--synchronizing block; БН--guidance block; СОС--feedback system; ПГУ--servo control unit; ЭК1 and ЭК2--electronic switches; У1 and У2--power amplifiers; ШД1 and ШД2--step-by-step motors; К--channel of feedback on speed; see the other symbols in Figures 1 and 3.

The direction of the movement of the motor М (the hydraulic cylinder or the hydraulic motor) is selected in the guidance block БН on the command from the microcomputer. If a positive direction of movement is specified, the sequence of pulses from the ЦИ is fed into electronic switch ЭК1 of step-by-step motor ШД1, while the sequence of pulses from the ДОСП is fed into electronic switch ЭК2 of step-by-step motor ШД2. If a negative direction of movement is specified, the sequence of pulses of ЦИ and ДОСП changes.

The general algorithm of the the interaction of the microcomputer and the equipment portion of the drive is shown in Figure 5. The supervisory program 1 carries out the preparation of the microcomputer and the drive for joint operation. Upon completion of the evaluation of the control signal the microcomputer restores the initial state of the operating registers and waits for the next interrupt pulse, with the arrival of which the evaluation is repeated.

With the presence in the main program of the operation of accelerated displacement the channel К (see Figure 4) of feedback on the speed is blocked; here under the influence of the sequence of signals from the ЦИ the slide valve distributor of the servo control unit is displaced to the arresting device in the extreme position and remains there until the completion of the mode of accelerated displacement. Thus, the speed of accelerated

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displacement is governed by the maximum capacity of the pumping station (in practice the speed of accelerated displacement of the servo unit was up to 10 m/min).

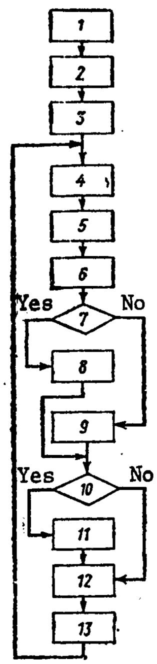

Figure 5. Algorithm of the Interaction of the Microcomputer and the Equipment Portion of the Servodrive; 1--supervisory program; 2--resetting of the signals of the БРП and БРОС; 3--start of the ГТП, БС and ЩИ; 4--beginning of the running of the interrupt program, recall of the operating modes; 5--reading of the БРОС; 6--evaluation and correction of the control signal; 7--positive direction of displacement; 8--signal "forward" in the БН; 9--signal "back" in the БН; 10--there is an operation of accelerated displacement; 11--blocking of channel K; 12--record in БРП; 13--restoration of the initial state of the operating registers, end of the running of the interrupt program

The main working program of the evaluation of the control signal takes up 60 cells of the memory ОЗУ, the supervisory program takes up 25 cells (the time of its operation is not included in the cycle of evaluation of the control signal) plus 20 cells for the constants, the input and intermediate data.

When building a drive according to the proposed structure (see Figure 4) at a maximum frequency of interruption of 500 Hz (the output of codes of control data at a frequency in excess of 500 Hz is not required) the Elektronika-NTs-03 microcomputer controls three drives. The time of a cycle of the evaluation of the control data according to the proposed algorithm (see Figure 5) for one drive is 0.5 ms, the time reserve is 0.5 ms. At a frequency of the output of the codes of control data, which is equal to 200 Hz, the time reserve in the case of three-coordinate control is 3.5 ms (the speed of the microcomputer is not less than 90,000 operations per second).

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In additional to a single-step servo control unit a high-torque DC motor can be used as the servomotor.

The tests of the microprocessor servodrive confirmed its efficiency and acceptable precision (the coefficient of the increase in speed in a stable mode was set at up to 100 s^{-1}). The duration of the transient response in the experimental system, in which a G15-2 hydraulic motor was used as the servomotor, was 6-7 ms.

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Conference on Computer-Assisted Control

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 80 p 37

/Article by B. S. Pitskel': "The All-Union Scientific and Technical Conference 'The Development of Integrated Computer-Assisted Control Systems at Machine Building Enterprises'"/

/Text/ The conference, which was organized by the Central and Omskaya Oblast Scientific and Technical Society of the Machine Building Industry, the USSR State Committee for Science and Technology and the machine building ministries, was held in Omsk from 12 to 14 September 1979. At the plenary sessions the most important reports were heard and the decision of the conference was adopted; the other reports were delivered at the meetings of the six sections ("Systemwide Questions of the Development and Operation of Automated Control Systems," "Computer Complexes and the Collective Use of Computers," "Automated Control Systems of Technological Processes," "The Use of Computer Hardware in the Control of Machine Tools and Units," "The Automation of Instruction at the Higher Educational Institution on the Basis of Computers").

First Secretary of the Omsk City Committee of the CPSU Ye. A. Norka delivered the opening address to the participants. He told about the introduction at enterprises of Omsk and Omskaya Oblast of integrated automated control systems, which cover questions of planning, dispatching and the control of technological equipment from computers.

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The reports at the plenary meetings were devoted to /modern equipment/ /in boldface/, which ensures the development of automated control systems. Thus, K. V. Peselev (Moscow) told about new computers of series YeS and SM; V. A. Ratmirov (Moscow) acquainted the participants with the new generation of devices of numerical program control, which are built on the basis of small computers, and with the problems which arise when developing the sections of machine tools with several levels of the hierarchy. Moreover, a number of reports were devoted to /the increase of production efficiency/ /in boldface/ owing to the use of automated control systems of technological processes.

The reports on /the experience of operating already existing automated control systems of technological processes/ /in boldface/ aroused the greatest interest of the conference participants. The speakers touched upon the important question of the need to determine the dependences of the main indicators of product quality on the technological parameters for the drawing up of scientific and technical documents which are used in developing automated control systems. Thus, the report of V. I. Bulgakov[1] (Kuybyshev), which was devoted to the experience of operating an automated control system of the technological processes of the molding of microcable, which is designed for the overall control of production and for immediately controlling the process of molding, told about the identification of the main technological parameters of the process of molding, which influence the product quality. The report of V. I. Zaborovskiy (Kishinev) was devoted to a description of the hierarchical structure of the automated control system of the technological processes of molding microcable.

The /experience of developing automated control systems for machine building enterprises/ /in boldface/ (V. A. Malakhovskiy, Omsk) and the development of automated control systems of the bench tests of engines, clutches and brakes (N. Yu. Batin, Khar'kov) were told about at the conference. A set of equipment for gathering and preparing data (KSPD-1), which is a system with the remote gathering of data which includes terminal equipment controlled by a general-purpose small computer, was also described (Ts. N. Perel'shteyn, Kazan').

Many reports were devoted to /machine tools and units with numerical program control/ /in boldface/. Thus, in his report A. G. Rozinov (Moscow) reported on the building of control systems of automatic lines on the basis of programming equipment, particularly on single-processor programmable command equipment. A. S. Chubukov (Moscow) delivered a report on one algorithm which is used for controlling a grinder. I. R. Podzolov (Odessa) reported on an automated control system of milling machines on the basis of an S5-12 small computer.

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1. Here and below only the first author of the report is indicated.

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The report of V. N. Borovik (Kiev) on /the software of the system of dynamic control of a section of machine tools with numerical program comtrol/ /in boldface/ aroused great interest. This system has been introduced and is in operation at several enterprises. During the discussion of this report the speakers directed attention to the fact that the computer, which controls the section, can be used for translating the general language into the mnemonic codes of each machine tool. This makes it possible to use the computer for the control of machine tools with numerical program control, which have different programming codes (ISO, BTsK-5 and so on) and different program carriers (perforated tape or magnetic tape).

A considerable portion of the reports were devoted to /algorithms of the optimization of technological processes and problems of the software of automated control systems of technological processes/ /in boldface/. Thus, the problem of linear programming with a large number of zeroes in the matrix of coefficients in the presence of unknowns was examined in the report of Ye. A. Karagodova (Kiev) on the algorithm of the formation of a production program for enterprises of the discrete type. The report of V. D. Diptan (Kiev) told about the solution of the problem of circumventing the points of drilling of plates by the shortest path by means of the algorithm of the computer designing of programs of the control of drilling on machine tools with numerical program control.

Several reports were devoted to /simulation models of automated control systems/ /in boldface/. At times the model is a queuing system, while the solution is obtained by analytical methods (Ye. F. Babushkin, Riga). However, as the discussion at the conference showed, more often an attempt is made to study the system not by analytical methods, but by means of computer-assisted modeling. Here the GPSS/360 modeling system (a package of applied programs) is used, as, for example, in the study of the productivity of automatic lines (Ye. I. Korovyanskaya, Moscow), in the solution of the problem of scheduling for the machine building enterprise (V. G. Mogila, Kurgan), in the study of the characteristics of the use of equipment in automated complexes made up of machine tools with numerical program control, which are controlled from a computer (A. V. Zav'yalov, Moscow).

In many reports, which were devoted to /the mathematical modeling of automated control systems/ /in boldface/ or some aspects of it (economic, information, reliability), they examined in addition, on the basis of what data one model or another should be built.

Much attention was devoted to /systems of the automated designing of automated control systems/ /in boldface/. In particular, they told about the multistage model of the synthesis of automated control systems on the basis of collective-use computer equipment (Ye. M. Kalganov, Omsk), the automated designing of the technological processes of assembling (V. V. Pavlov, Moscow), the automation of the modeling of nonlinear systems of automatic control (V. G. Ivanenko, Moscow) and others.

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The conference participants familiarized themselves with the work of a number of industrial enterprises of Omsk. In the decision of the conference the most important directions in the development of the software and hardware of automated control systems were indicated and specific recommendations on the use of the results of the performed developments were given.

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USSR REPORT: Construction and Equipment
USSR REPORT: Military Affairs
USSR REPORT: Political and Sociological Affairs
USSR REPORT: Energy
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USSR REPORT: Transportation
USSR REPORT: Translations from KOMMUNIST*
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USSR REPORT: USA: ECONOMICS, POLITICS, IDEOLOGY*

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USSR REPORT: Life Sciences: Effects of Nonionizing Electromagnetic Radiation
USSR REPORT: Life Sciences: Agrotechnology and Food Resources
USSR REPORT: Chemistry
USSR REPORT: Cybernetics, Computers and Automation Technology
USSR REPORT: Electronics and Electrical Engineering
USSR REPORT: Engineering and Equipment
USSR REPORT: Earth Sciences
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USSR REPORT: SPACE BIOLOGY AND AEROSPACE MEDICINE*

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