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USSR Report

CONSTRUCTION AND EQUIPMENT

(FOUO 6/80)

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USSR REPORT

CONSTRUCTION AND EQUIPMENT

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METALWORKING EQUIPMENT

USE OF VARIOUS MACHINE TOOLS WITH NUMERICALLY PROGRAMMED CONTROL

Results for 1980 Discussed

Moscow STANKI I INSTRUMENT in Russian No 3, Mar 80 pp 1-2

/Article: "A Year of Successful Labor"/

/Text/ The patriotic movement to commemorate the 110th anniversary of Lenin's birth, the leader of the workers of all nations, the impassioned revolutionary and creator of the Communist Party of the Soviet Union and the world's first socialist state, is now well underway in the Soviet Union.

Soviet workers under the guidance of the CPSU are giving all their efforts, knowledge and energy to the struggle to successfully fulfill the assignments of the Tenth Five-Year Plan, the decisions of the November (1979) Plenum of the CPSU Central Committee, and the orders and directives expressed by L.I. Brezhnev in his speech at the November Plenum.

Nearing the holiday, the workers of the machine tool and instrument building industry are industriously and creatively solving the tasks of the final year of the Tenth Five-Year Plan.

The enterprises and organizations have enthusiastically responded to the appeal of the collective of the Moscow Machine Tool Building Plant imeni Sergo Ordzhonikidze to undertake a socialist competition to overfulfill the 1980 plan and to create a solid foundation for the successful inauguration of the Eleventh Five-Year Plan.

The Moscow Machine Tool Building Plant has made these pledges: to conclude fulfillment of the Tenth Five-Year Plan for volume of production before the 63rd anniversary of the October Revolution; to produce 17 million rubles worth of additional product by the end of the year; to fully ensure an increase in product by raising labor productivity; to reduce the labor intensiveness of product by 4.2 percent; to realize 200,000 rubles in above-plan profit; to conserve 120 metric tons of ferrous metal and 7,850 kilowatt-hours of electric energy. The plant is also working to fulfill pledges in the area of assimilating new technology and raising its quality.

In the first six months of 1980 they will manufacture 50 machine tools with numerically programmed control in excess of the plan. Through the introduction into the national economy of equipment that the plant produced during the Tenth Five-Year Plan, they will save 75 million rubles.

In response to the CPSU Central Committee Decree "Concerning the Tenth Aniversary of Lenin's birth", workers of the Ryazan' Machine Tool Building Production Association have pledged to fulfill the annual plan ahead of schedule and to produce 500,000 rubles worth of additional goods. Altogether for the five-year plan 5.5 million rubles worth of above-plan product will be manufactured. More than 4,000 of the association's workers have pledged to fulfill the five-year plan assignment ahead of schedule; 2,000 pledged to do so by the 110th anniversary of Lenin's birth.

The collective of the Zaporozh'e Abrasives Combine imeni 50 Years of the Soviet Ukraine has made these socialist pledges for 1980: to produce by the third anniversary of the new Soviet constitution 300,000 rubles worth of above-plan product; to complete the Tenth Five-Year Plan for production of goods by the 63rd anniversary of the October Revolution; to produce 10.7 million rubles worth of product in excess of the five-year plan assignment; and to conserve 3 million kilowatt-hours of electricity and 350 tons of conventional fuel.

Similar socialist pledges for overfulfilling assignments for product output, the extensive use of production reserves, the assimilation of new technology, the rational expenditure of material resources, raising production efficiency and the quality of work have been made by all collectives of the enterprises and organizations of the USSR Ministry of the Machine Tool and Tool Building Industry.

The year 1980 is a new and important step in the development of Soviet production forces. It is the concluding year of the Tenth Five-Year Plan, the year to prepare for the successful start of the Eleventh Five-Year Plan, and the year to prepare for the 26th CPSU Congress.

During the past four years a solid foundation was laid for solving the national economic tasks of 1980. Since the beginning of the five-year plan, the USSR has significantly advanced in the development of the national economy and the further raising of the material and cultural well being of its people. During the four years Soviet national income increased by 16.2 percent as compared with the same period of the Ninth Five-Year Plan. The value of fixed assets as of 1 January 1980 was greater than one trillion rubles; capital investments exceeded 500 billion rubles; and nearly 1,000 large enterprises were equipped.

The material and technical base of agriculture is being expanded and modernized. During the four years of the Tenth Five-Year Plan agriculture received 1.5 million tractors, 426,000 grain combines, and 317 million tons of fertilizer; gross agricultural product increased during this period by more than 40 billion rubles.

As a result of the rapid development of the branches that determine technical progress, the structure of industrial production was improved. While the volume of industrial production in 1979 as compared with 1975 increased by 20 percent, in the machine tool building and metal working industries volume increased by 40 percent and in the chemical and petrochemical industries by 25 percent.

Based on the successes in economic construction there was a rise in the material and cultural standard of living of the people. Real income per capita for the four years increased by more than 13 percent; retail goods turnover in comparable prices increased by 18 percent; 423 million square meters of housing were built; and public consumption funds amounted to 410 billion rubles.

The USSR Supreme Soviet approved a state plan for the economic and social development of the USSR in 1980 which defined the basic levels for the concluding year of the Tenth Five-Year Plan and for the further development of the Soviet economy in accordance with the decisions of the 25th CPSU Congress.

The 1980 state plan calls for a substantial increase in the absolute growth of public wealth in industrial and agricultural product. Soviet national income will increase by 4 percent; the volume of industrial production will rise by 4.5 percent; and gross agricultural product will increase by 8.8 percent. Real income will increase by 2.9 percent; for the entire five-year plan income will rise by 16.6 percent.

The 1980 plan called for a concentration of resources for the development of essential links in the economy - the fuel and raw materials base, power, transport, metallurgy, machine building, the chemical industry and others.

The 1980 plan called for high rates in the development of machine building. On the whole the production of product for the machine building and metal working industries will increase as compared with 1979 by 6.5 percent. Assignments have been determined for improving the structure for manufacturing machinery and equipment and for increasing the percentage of new, more productive and economical kinds of machinery and equipment.

During the last four years of the Tenth Five-Year Plan the machine tool building and tool building industry developed at high rates. Positive results were achieved in improving the structure of the manufacture of metal working equipment, equipment for the casting industry, wood working equipment and tools. The machine tool building industry increased the volume of consumer goods production 1.41-fold as compared with 1975. The structure of manufacturing through the use of a substantial increase in the production of more efficient kinds of product was improved. With a total increase in the production of metal cutting machine tools in 1979 (as opposed to 1975) of 4.4 percent, the production of special machine tools and assemblies increased by 34 percent. The production of high precision machine tools increased by 24 percent.

The manufacture of metal cutting machine tools with numerically programmed control increased by 54 percent in 1979 as compared with 1975. During the past four years of the five-year plan more than 1,100 forge-and-press machines with programmed control were manufactured; the total output of forge-and-press machines in 1979 as compared with 1975 increased by 14.4 percent.

During the first years of the Tenth Five-Year Plan the output of casting equipment exceeded the output of the preceding five-year plan (in comparable prices) by 36.6 percent, the output of metal working tools by 11.8 percent and of diamond tools by 57.6 percent.

The realization of measures to re-equip enterprises, to adopt progressive technology and to improve the organization of production and labor made it possible during the four years of the five-year plan to increase labor productivity as compared with 1975 by 31 percent and as the result of this to obtain a more than 78 percent total growth in consumer goods output.

The enterprises and organizations of the sector are devoting continuous attention to matters concerning the raising of the technical level of the equipment and tools that are being manufactured. A percentage of highest category of quality product of the total amounted to 32.5 percent in 1979. During the four years of the Tenth Five-Year Plan 1,725 experimental models of new machine tools and machines were created; 1,380 adjustable banks of machines were manufactured; and 900 antiquated manufactured articles were removed from production.

The Orsha Machine Tool Building Plant "Krasnyy borets" is successfully assimilating the production of a complex range of face grinding machine tools with numerically programmed control for the high-speed and subsurface polishing of materials. The new machine tools, which have been certified with the State Mark of Quality, provide a rise in labor productivity of 2.8 times as compared with machine tools previously manufactured.

The Odessa Precision Machine Tool Plant imeni 25th CPSU Congress in 1979 assimilated the manufacture of ten experimental models of metal cutting machine tools. The plant assimilated the production of a range of vertical high precision honing semiautomatic tools.

At the Ul'yanov Heavy and Nonstandard Machine Tool Plant they have manufactured a linear-milling, double-housing machine tool, model 662oMF4, with numerically programmed control. The machine tool is fitted with a vertical carrier drill chuck and a system for the automatic shift of the tool (there are 40 tools) and is intended for the processing of complicated curved surfaces. The machine tool's productivity is three times greater than for all similar machine tools.

In the final year of the Tenth Five-Year Plan the machine tool building sector must provide a growth in production as compared with 1979 of 8.1 percent, including the output of special and assembly machine tools which must be increased by 12.9 percent, machine tools with numerically programmed control by 18.3 percent, automatic and semiautomatic production lines for machine building and metal working by 22.5 percent, production lines for the casting industry by 14 percent. The production of consumer goods must be increased by 8.1 percent in 1980. By raising labor productivity there must be an 80 percent growth in the volume of marketable product.

The fulfillment and overfulfillment of the assignments of the 1980 state plan, the elimination of shortcomings in the management and organization of production that were brought to light in preceding years, and the better use of existing reserves are the basic factors for the successful inauguration of the Eleventh Five-Year Plan for the machine tool and tool building sector.

Managers at all levels on the basis of the analysis of work in 1979 must make correct, practical conclusions for improving the management of production and concentrate their attention on carrying out measures aimed at raising the effieiecny and quality of work.

To solve the tasks of the current year and prepare the sector for the Eleventh Five-Year Plan it is necessary to ensure that all enterprises fulfill without fail the planned assignments for product output and growth of labor productivity.

An important prerequisite of successful work, just as in previous years, is the speeding up of the introduction of new production capacities, the full accomplishment of plans for the re-equipping of enterprises and also the capital construction plans.

The plan for the development of science and technology in 1980 called for the manufacture and testing of 480 experimental models of highly productive equipment (including 315 metal cutting machine tools), and also the output of 397 adjustable banks of equipment. Improving the structure of the manufacture of metal cutting machine tools will be directed, primarily, at a significant increase in the percentage of automated machine tools of all technological groups, machine tools with numerically programmed control, and automatic production lines and complexes. In 1980 the USSR Ministry of the Machine Tool and Tool Building Industry must bring the percentage of highest quality product to 40 percent of the total manufactured.

The design and production organizations of the sector must initiate work to significantly reduce the consumption of metal and energy for manufacturing machine tools and machines.

To maximize the use of existing reserves there must be a rise in the standard of management at all working levels and a strengthening of production, technological and planning discipline. The fulfillment of planned assignments and decisions that were made must be constantly monitored.

It is necessary to immediately carry out all comprehensive measures, which were drawn up in accordance with the CPSU Central Committee and USSR Council of Ministers Decree "Concerning the improvement of planning and strengthening the influence of the economic mechanism upon raising production efficiency and the quality of work."

The end of the five-year plan is fast approaching. The collectives of the enterprises and organizations of the USSR Ministry of the Machine Tool and Tool Building Industry are applying all their knowledge and energy to ensure the fulfillment and overfulfillment of 1980 planned assignments.

Metal Cutting Equipment

Moscow STANKI I INSTRUMENT in Russian No 3, Mar 80 pp 3-8

/Article by L. S. Bron and V. S. Vasil'ev: "Resettable Automatic and Automated Metal Cutting Equipment"/

/Text/ The readjustment of automatic and automated equipment, and particulary automatic production lines (AL), which is called for in planning, provides significant economic savings in the following instances.

1. In conditions of large-scale series and mass production: when it is necessary to periodically modernize the machines being manufactured by changing the objects of production; for the complete loading of equipment by manufacturing on each AL several modifications of stereotype parts; for increasing the output of different modifications of machines by the parallel or sequential processing of their parts on available equipment.

2. In conditions of series production for a substantial increase in labor productivity by the sequential multi-tool processing of complex housing parts.

We shall now examine the status and possibilities for resetting both the existing * and the newly created resettable automated and automatic equipment (PAO).

Automatic production lines for large-scale series and mass production, which are composed of special, specialized or standard machine tools, are intended for processing one (previously assigned) part (solid of revolution type) with the manufacturing program that provides for the full loading of the automatic production line for the year. When necessary such production lines can be reset (by refitting the supports, changing the technological rigging, regulating the transport system and adjusting the control systems) for processing other (previously unknown) parts of similar design and processing technology. The range of part sizes is limited by the characteristics of the equipment built into the automatic production line.

* L. S. Bron, Automated production lines for mass and large-scale series production. STANKI I INSTRUMENT, 1979, No 2, pp 5-6.

With the advance manufacture of interchangeable parts of set ups and transport systems the time for resetting an automatic production line (with the shut down of equipment) is 8 to 10 changes. However, these automatic production lines are presently reset very rarely since the design of the parts that are processed on them is stable and the program for manufacturing just one part provides full loading of the line for a year.

Automatic production lines, which are assembled from modular machine tools, are intended for the processing of one (previously assigned) part of the housing type. Such automatic production lines can be rebuilt to process another (previously unknown) part when there is a change in the objects of production. However, the rebuilding of a line (by reassembling the built in equipment and particularly the standardized units) requires a considerable amount of additional work: the manufacture of new spindle boxes and tool rigging, and the additional assembly of housing parts, and so forth. Therefore the resetting of traditional automatic production lines, which are assembled from modular machine tools, is, as rule, unsuitable.

The adjusted lines comprised of modular machine tools are lines that are intended for processing one (previously assigned) housing part, during the planning of which provision is made for building in reserve equipment: power tables, angles, transport and control devices and so forth. This equipment can be used later to process an assigned part of a new modification or another (previously unknown) part of similar design.

To reset an automatic production line for the processing of new parts requires 6 to 8 months (including nearly one month with a total shutdown of production). The manufacture of a reset automatic production line with additional equipment increases its cost by 10 to 20 percent.

The complex of such resettable automatic production lines, which was designed by the Moscow Special Design Bureau of Automatic Production Lines and Modular Machine Tools and manufactured by the Moscow Machine Tool Plant imeni Sergo Ordzhonikidze, was used at the ZIL /Plant imeni Lenin/ for processing two modifications of cylinder units. The creation of such lines in the future will depend upon orders from customers.

Resettable automatic production lines, which are intended for the sequential processing of several modifications of uniform parts, are suitable for use when the manufacturing program for one part does not provide for the full loading of the equipment during the course of a year. Up to two shifts are needed for the resetting. Such automatic production lines, which were designed by the Experimental Scientific-Research Institute of Metal Cutting Machine Tools and manufactured by the Plant "Machine Tool Design" of the same institute, are used to process shafts and rotors for four different sizes of asynchronous electric motors.

Resettable automatic production lines and modular machine tools, which are assembled from modular machine tools (or special machine tools), can also be used for the simultaneous or sequential group processing of several (up to 4 or 6) previously assigned parts that are similar in design. Such modular machine tools and automatic production lines are assembled from standard units *, which are used for manufacturing non-resettable equipment.

The resetting (manual or automatic) for sequential processing of parts is accomplished by switching on or off individual power units or by changing the spindle boxes. The number, types and characteristics of the spindle boxes must provide for the fulfillment of the required technological operations for processing the entire groups of parts. Up to 30 minutes are required for resetting.

This kinds of automatic production line, which was designed by the Minsk Special Design Bureau of Automatic Production Lines and manufactured by the Minsk Automatic Production Line Plant, is used for processing the collector of a locomotive engine (in four sizes).

For greater flexibility and rapid resetting of the control systems of resettable automatic production lines (all types) in recent times they have been using free programmable command apparatuses, which, however, do not solve the problem of raising the capability of being reset for the mechanical units of the resettable automatic equipment. ** The technical solutions, connected with the manufacture of all of these resettable automatic equipments, have been worked out, which makes it possible (if there are orders) to increase their output in the Eleventh Five-Year Plan.

Thus, the resettable automatic equipment, which has been assimilated and is now being manufactured, is basically intended for the highly productive processing of a small product list of previously known parts in conditions of large scale series and mass production.

At present there is a need for the automatic production lines and their complexes to be used for the simultaneous or sequential processing of a wider product list (up to 10 or 12 items) of housing parts that are similar in purpose and size in conditions of mass production. The creation of such equipment on the basis of existing standard units is not always possible, because different modes of cutting (automatically switching) and tool rigging are required for the processing of each individual part.

Analysis shows that many complicated housing parts of tractors, combines, automobiles, engines and other equipment and the spare parts for them must be manufactured in repeating batches (50 - 200 items) with an annual output of 5,000 to 50,000 items (i.e., in conditions of series production).

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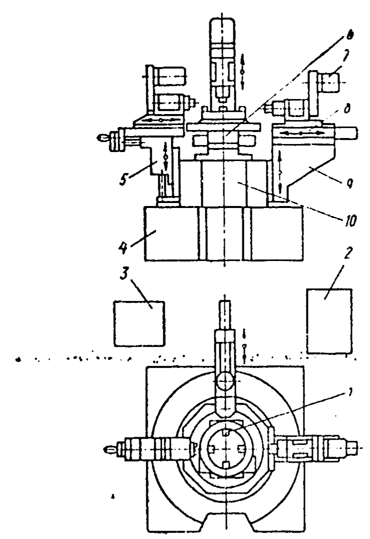
* L. S. Bron, A unified range of standard units for modular machine tools and automatic production lines. STANKI I INSTRUMENT, 1979, No 5, pp 14-17.

** L. S. Bron and B. I. Cherpakov, Raising the efficiency of operation of automatic production lines through the use of computers. STANKI I INSTRUMENT, 1976, No 8, pp 34-38.

The expansion of the product list of parts manufactured by the group method in conditions of large-scale series and mass production and also the need to substantially raise the productivity of processing complicated housing parts in conditions of series production have led to the creation of basically new highly productive resettable modular machine tools (PAS) and resettable automatic production lines (PAL) based on modules of standard units. The processing of parts on this equipment is done in sequence using multi-spindle boxes, which are substituted automatically.

Below we see models of modern PAS and PAL modular units, the use of which significantly raise labor productivity when processing complicated housing parts in conditions of series production.



Drawing 1. A standard small PAS

1. Part being processed
2. Electrobox
3. Hydrostation
4. Mounting
5. Vertical skids
6. Continuous dividing table
7. Power head
8. Horizontal skids
9. Support
10. Column

The small PAS (Drawing 1), which was designed by the Khar'kov Special Design Bureau of Modular Machine Tools and manufactured by the Khar'kov Modular Machine Tool Plant, is to be used for processing a group of parts, previously assigned by a customer. The part 1 is placed on the continuous dividing table 6 (directly or with the use of a clamp attachment).

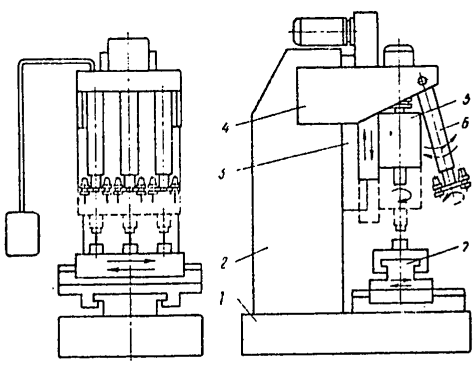
The machine tool consists of standard modular units, with the use of which various configurations of the PAS are possible. The following operations are performed on the machine tool: drilling, countersinking, hole enlarging, rounding, threading, preliminary boring and milling.

The machine tool is reset manually by replacing the clamp attachments, installing new sets of spindle adapters, changing the cutting modes, and reprogramming the sequence of operation of the power units.

Technical characteristics

Maximum dimensions of parts to be processed (length X width X height) in millimeters	100 X 100 X 100
Diameter of the faceplate of the turning table, mm	320
Maximum motion of power units, mm	160
Maximum motion of supports of the vertical displacements, mm	100
Maximum power of power unit, in kilovolts	.55
Feed drive	Hydraulic
Maximum number of working positions	8
Dimension of machine tool with hydroequipment and electrobox (width X length X height), mm	3000 X 2800 X 2000

The multi-tool PAS, model KhPA5 (Drawing 2) with numerically programmed control, which was designed by the Khar'kov Special Design Bureau of Modular Machine Tools and manufactured by the Khar'kov Modular Machine Tool Plant, is intended for multi-flow-line processing (by one tool) of parts in conditions of series and small-scale series production. Three parts of the same designation are processed simultaneously. All three spindles perform the same operations and the tool magazines are fitted with the same sets of tools. The clamp attachments and the parts being processed are installed on the cross table 7.



Drawing 2. Multi-tool PAS, Model KhPA5 with numerically programmed control:

1. Bench
2. Vertical stand
3. Power table
4. Support
5. Power drill
6. Tool magazine-auto-operator
7. Cross table

Technical characteristics

Maximum dimensions of parts to be processed (length X width X height), mm	300 X 200 X 250
Number of spindles	3
Power of main drive, kilovolts	4, 3

Maximum displacements of cross table, mm	
by X axis	560
by Y axis	360
Maximum number of tools installed in the magazine of one spindle	6

On the basis of the different modifications of modern PAS and PAL, which are intended for processing housing parts of large size (in contrast to traditional modular machine tools and automatic production lines composed of modular machine tools), is placed the principle of the sequential carrying out of technological operations for processing a part in one working position, in which multi-spindle tool boxes with appropriate sets of tools are automatically (in sequence) put into processing position. The movement of the feed is accomplished by a power unit, on which can be installed either a part to be processed (for the duration of its processing) or the next spindle box.

The total time T_s of processing of one surface of the part is determined by the addition of the time of the technological transfers and the time expended for changing the spindle boxes: $T_s = nt_T + (n-1)\,t_{sh\ p}$, where t_T is the time of one technological transfer; n - number of transfers; $t_{sh\ p}$ is the time for replacing one spindle box.

The total time for processing a part from several sides

$$T_0 = \sum_1^i T_c + (i-1)\,T_n + t_y + t_c,$$

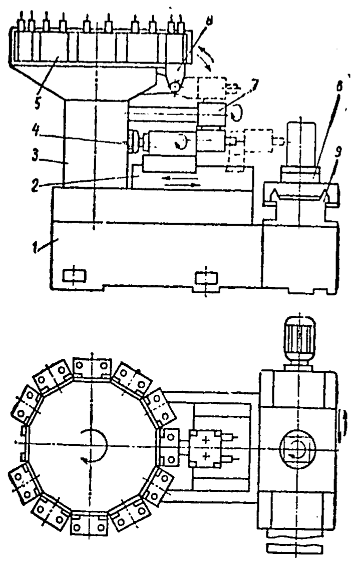
where i - number of sides of a part processed on the PAS; T_p - the time for replacing or turning the part; t_y and t_s - the time for placing and removing the part, respectively.

The high productivity of PAS (as compared with multi-tool machine tools with numerically programmed control) is brought about by the fact that each technological transfer is accomplished by a group of tools working simultaneously. Moreover, on the PAS it is possible to process batches of various parts by replacing (manually or automatically) the spindle boxes.

Below are cited the configurations of PAS and PAL with replaceable spindle boxes.

PAS, model KhPA4 (drawing 3) with numerically programmed control was designed by the Khar'kov Special Design Bureau of Modular Machine Tools and manufactured by the Khar'kov Modular Machine Tool Plant. It is intended for processing housing parts. The multi-spindle boxes are substituted automatically. It performs these operations: drilling, threading, milling, boring. Resetting of the machine tool for processing various parts by replacing the set of multi-spindle boxes (with tools and conductors), the remote attachment and the programming carrier.

On the lengthwise portion of the T-shaped bench 1 is installed a power table 2, on the moveable carriage of which is fastened a power drill 4. The power table 2 is covered by an arched column 3, on which is installed a magazine of changeable multi-spindle boxes 5.



Drawing 3. PAS, model KhPA4 with numerically programmed control:

1. Column (bench)
2. Power table
3. Column
4. Power drill
5. Multi-spindle box
6. Floating hand
7. Autooperator
8. Continuous dividing table
9. Index-power table

The transfer of the boxes from the magazine into the power drill 4 and back is accomplished by a floating hand 6 and the autooperator 7.

On the transverse portion of the bench 1 is installed an index-power table 9, on the moveable carriage of which is installed a continuous dividing table 8, where the clamp attachments are located with the parts being processed.

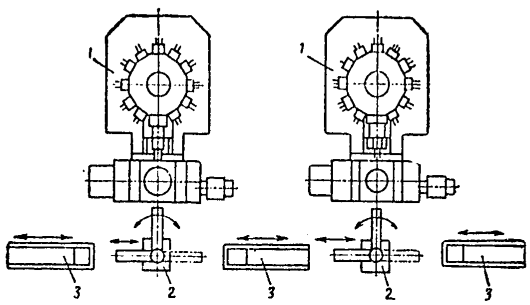
Processing is done by the horizontal displacement of the power drill. The installation of the part being processed in the working position is accomplished by the displacement of the index-power table. The required indices of openings is provided by the positioning of the spindles in the multi-spindle box. The positioning of the surface for processing is done by turning the faceplate of the continuous dividing table to the assigned angle.

Technical characteristics

Maximum dimensions of parts to be processed (length X width X height), mm	100 X 100 X 100
Power of main drive, kilovolts	3
Number of multi-spindle boxes in magazine ...	15

Diameter of faceplate of the turning table, mm ..	400
Number of divisions of turning table	24
Size of machine tool (length X width X height, mm	6040 X 4690 X 3200

The PAL (Drawing 4), which was designed by the Khar'kov Special Design Bureau of Modular Machine Tools, consists of machine tools 1 (See Drawing 3) with replaceable multi-spindle boxes, automatic manipulators 2 and transport-storage devices 3. The resetting of the line is accomplished by resetting the machine tools and also replacing the attachments, the clamps of the manipulators and the programming carriers in the numerically programmed control system.



Drawing 4. PAL consisting of machine tools with numerically programmed control:

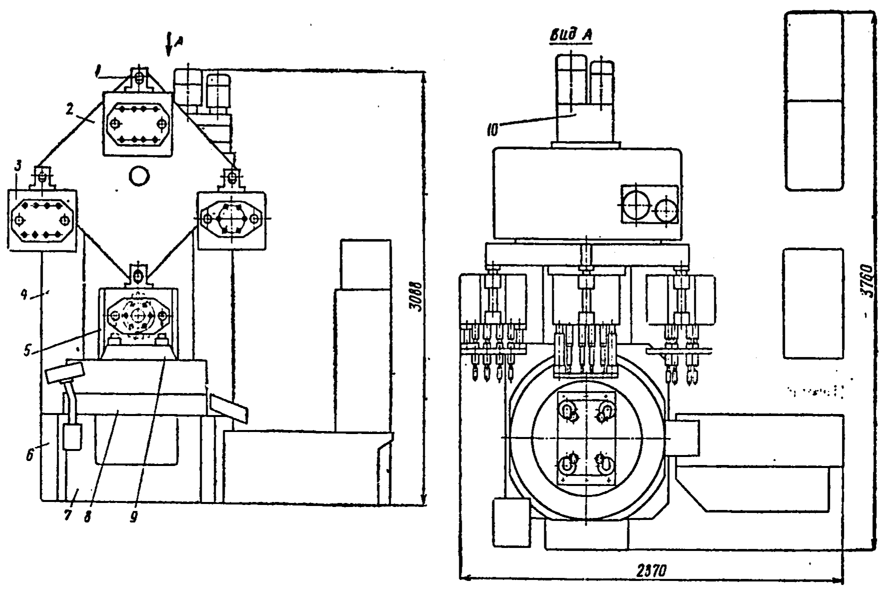
1. Machine tool
2. Automatic manipulator
3. Transport-storage device

The modular horizontal drilling and threading machine tool (Drawing 5) with a dividing and turning table and automatic changing of multi-spindle boxes was designed by the Minsk Special Design Bureau of Automatic Production Lines and manufactured by the Minsk Automatic Production Lines, is configured using standard units of a single range. [See footnote 1 on page 8]

The machine tool is intended for processing previously known housing parts with maximum dimensions (length X width X height) of 400 X 400 X 320 mm. The processing of all sides of a part is done in one setting.

The machine tool has a horizontal configuration. On the bench 7 is installed a turning table 8 with a clamp attachment fastened to it 9. On the side adapter 6 is installed a power table 10 with a power drill 5 and a portal 4, a carrying magazine of spindle boxes made in the shape of a drum 2 with pins 1, on which are hung spindle boxes 3. The spindle box, located in working position, is fixed and clamped on the forward face of the power drill 5, which informs it of the main movement and the movement of feed. To replace the spindle box the drum 2 is revolved a quarter of a turn. Moreover, the worn out spindle box is removed from the power drill and the next in cycle box is installed, fixed in place and clamped. The turning table 8 meanwhile is turning, adding to the cutting area the next side of the part being processed. The machine tool is controlled by using a relay automatic device or from the free programming comand apparatuses.

Resetting the machine tool for processing other parts is accomplished by replacing the set of spindle boxes and the clamping attachments. Two to three hours are needed for resetting.



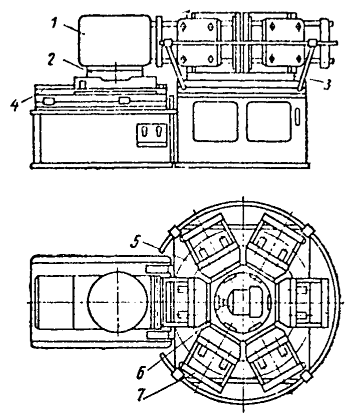
Drawing 5. Modular horizontal drilling and threading machine tool:
1 - Rod; 2 - Drum; 3 - Spindle box; 4 - Opening; 5 - Power drill;
6 - Adapter; 7 - Bench; 8 - Turning table; 9 - Clamping attachment;
10 - Power table

Technical characteristics

Power of main drive, kilovolts	5
Maximum number of spindle boxes	6
Size of machine tool (length X width X height), mm	3760 X 2870 X 3088

Drawing 6 shows a PAS design worked up the Moscow Special Design Bureau of Automatic Production Lines and Modular Machine Tools (manufactured by the Moscow Machine Tool Plant imeni Sergo Ordzhonikidze), on which the part being processed 1 is secured on a turning attachment 2 of the power table

4, which executes rapid changes in position and feed. The multi-spindle boxes 5 (2 - 6 of them) and conductor plates (or without the plates) are installed on the turning and dividing table 3. The main drive 6 is installed on a rigid foundation in the center of the table. In the operating position the main drive interacts with the intake shaft of the multi-spindle box. Control of change in position of the power table is accomplished by the use of supports and a unit of releases or from the numerically programmed control system. The turning attachment makes it possible to process a part on four sides in one setting.



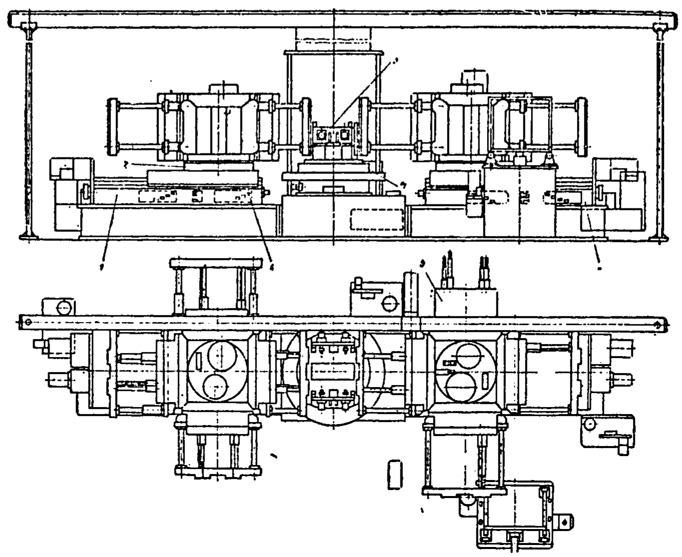
Drawing 6. PAS design worked up by the Moscow Special Design Bureau of Automatic Production Lines and Modular Machine Tools:

1 - Part being processed
2 - Turning attachment
3 - Turning and dividing table
4 - Power table
5 - Multi-spindle box
6 - Main drive
7 - Conductor plate

Drawing 7 shows a two-sided PAS design worked up by the Moscow Special Design Bureau of Automatic Production Lines and Modular Machine Tools with eight spindle boxes 5 installed on turning devices 2 of two power tables 1. The part being processed 3 is secured in a stationary attachment or on the turning table 4. The left and right power tables can operate simultaneously or in sequence.

The machine tool is quite versatile. On it it is possible to process (without resetting, in an automatic cycle) one side of a part with eight spindles in sequence, two sides of a part with four spindle boxes on each side, and four sides with two spindle boxes on each side.

Other variations are also possible both by replacing and not replacing the spindle boxes. When putting each spindle box into operating position the work cycle of the power table, the operating feed and other features are installed using terminal releases 6.

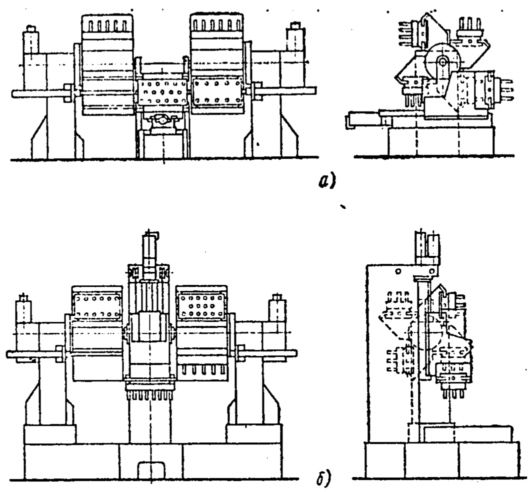


Drawing 7. Two-sided PAS design developed by the Moscow Special Design Bureau of Automatic Production Lines and Modular Machine Tools: 1 - Power table; 2 - Turning device; 3 - Part being processed; 4 - Turning table; 5 - Multi-spindle box; 6 - Terminal release.

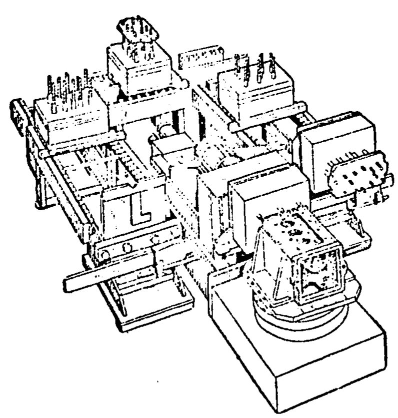
Drawing 8 shows the diagrams of the configurations of the PAS of the Huller-Hille Company (FRG). Drawing 9 shows the standard module PAO of the Renault Company (France).

The modular design makes it possible to use this PAO in various configurations (both as individual machine tools and as an automatic production sector built on the base of standard modules).

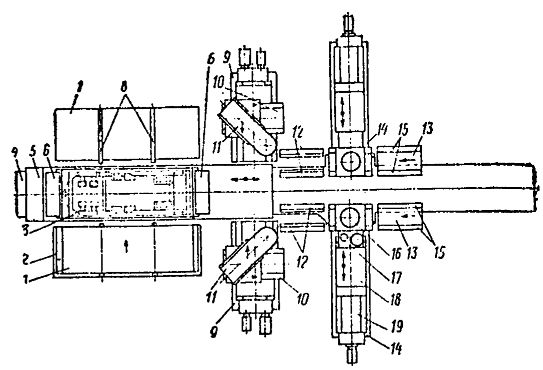
Drawing 10 shows a PAL for processing several modifications of tractor frames. The PAL was designed by the Minsk Special Design Bureau of Automatic Production Lines. The maximum size of the part being processed (length X width) is 4000 X 1300 mm. The following operations are performed on the production line: milling of the mounting plates; drilling and countersinking of bracket openings; and threading.



Drawing 8. PAS in horizontal (a) and vertical (b) configurations, manufactured by the Huller-Hille Company (FRG).



Drawing 9. Standard PAO module manufactured by the Renault (France) Company.



Drawing 10. PAL for processing several modifications of tractor frames

The part being processed is transported in attachments 1 and 3, which are alternately secured using devices for fixation and clamps 6 on a transverse multi-position table 5 of the transport device 4.

The transfer of the attachments to the table 5 (and back) is accomplished alternately from one of the two loading and unloading positions 2 and 7 in the initial position of the table. Moreover, the movement of the attachments takes place along guide rails 8. The table 5 is moved with the secured part in the attachment into the processing area to the milling machine tools 9 and then on to the drilling machine tools 14.

The milling of the plates is accomplished by two lateral milling heads 11, which are installed on the cross tables 10, which move in lengthwise and transverse directions. Following the milling of the first group of plates, the milling of the other plates takes place at the same time that holes are being drilled in the plates of the first group.

For resetting for the processing of a part of another modification the production line is supplied with a magazine of spindle boxes 13 (four boxes), which are situated in the magazine in guide gibs 12 and 15. The spindle boxes 13 automatically feed into the two power tables 17 with the power drills 16, which are secured on vertical stands 18, which in turn are installed on transverse multi-position tables 19.

Following processing of the part by the first pair of spindle boxes, the boxes are replaced and processing of the part continues. Moreover on the production line it is possible to process a part when positioning in a direction opposite to the initial direction. Upon completion of processing the attachment 3 (with a finished part) returns to the initial position, from where it moves into a neutral position of the loading and unloading device; the loading of the attachment 1 (with an ingot) onto the lengthwise table 5 takes place here.

To reset the production line it is sufficient to replace the spindle boxes in the magazine and make (when necessary) a readjustment of the clamp elements on the attachment and change the processing cycle. It takes up to 8 hours to reset. The production line can process four parts each hour. The production line replaces three lengthwise milling machine tools and eight radial boring machine tools.

Below are cited data showing the capability of performing several technological operations on various kinds of PAO.

Type of PAO	Multi-tool machine tools with numerically programmed control (MS)	Sectors with MS with numerically programmed control	Automatic production lines and modular machine tools for group processing	Sets of automatic production lines of modular machine tools for group processing	PAS and PAL
Drilling, hole expanding, countersinking and rounding	Yes	Yes	Yes	Yes	Yes
Threading	Yes	Yes	Yes	Yes	Yes
Surface milling:					
roughing	Yes	Yes	Yes	Yes	No *
finishing	Yes	Yes	Yes	Yes	No *
Planing of grooves and channels	Yes	No	No	No	No
Boring of holes:					
Roughing	Yes	Yes	Yes	Yes	Yes
Finishing	Yes	Yes	No	Yes	No *
Surface extending	No	No	No	Yes	No
Honing	No	No	No	Yes	No
Size control	No	Yes	Yes	Yes	No *
Washing, drying and so on	No	No	No	Yes	No *
Assembly	No	No	No	Yes	No

* These operations will be performed to the extent that the appropriate standard units for the PAO have been developed.

The following table provides approximate data concerning the automatic and automated metal cutting equipment (in use and being created) that is intended for processing housing parts (of the box type) in various production conditions; the maximum dimensions (length X width) of the parts to be processed in a processing plane of 1250 X 800 mm.

The data makes it possible to determine the field of practical use of the PAO and the automatic production line. When selecting and ordering specific equipment it is necessary to estimate the economic efficiency of various variations with consideration of capital expenditures.

Вид оборудования	Тип производства	Число типоразмеров или модификаций обрабатываемых деталей	Минимальное число деталей в партии (в числителе) и минимальное общее число деталей одного наименования, подлежащих обработке (в знаменателе)	Время обработки детали, мин	Годовой выпуск деталей, шт.	Число инструментов при работе в автоматическом цикле	Число одновременно работающих инструментов	Возможность и время переналадки оборудования: при переходе на обработку заранее известных деталей	Возможность и время переналадки оборудования: при переходе на обработку новых деталей	Повышение производительности труда (по сравнению с обработкой на универсальных станках)
Многоинструментные станки с ЧПУ	Единичное и мелкосерийное	В пределах технических характеристик станка	5—10 / 1000	60—420	350—3000	12—50	1	Возможна. Время остановки оборудования до 1—2 ч при заранее подготовленной оснастке с использованием УСП	Возможна. Время остановки оборудования до 4—8 ч (для отладки программы)	В 3,5 раза
Участки (линии из 5—6 многоинструментных станков), управляемые от ЭВМ	Мелко- и среднесерийное	30—50	20—50 / 1000	20—60	3000—9000	До 250	5—6	Возможна. Время остановки оборудования до 3,5 ч (для подготовки участка)	Возможна. Время остановки оборудования до 48 ч (без учета времени подготовки новых программ, изготовления оснастки и т. д.)	В 4,5 раза
ПАС и ПАЛ (из 1—2 модулей) с автоматической сменой шпиндельных коробок*	Среднесерийное	До 30	50—200 / 10 000	3—20	8000—50 000	До 800	15—35 (для ПАС); до 70 (для ПАЛ)	Возможна. Время остановки оборудования до 2 ч (для смены приспособлений и шпиндельных коробок)	Возможна. Время остановки оборудования до 20 ч (для смены приспособлений и шпиндельных коробок); для изготовления новых комплектов шпиндельных коробок и приспособлений требуется 6—12 мес.	До 15—20 раз
АЛ из АС (среднее число АС—7,5) для групповой обработки деталей	Крупносерийное и массовое	2—6	Не ограничено / 500 000	0,7—2	80 000—225 000	До 300	До 250	Возможна. Время остановки оборудования до 30 мин	Не предусмотрена	До 25 раз
АЛ из АС (среднее число АС—7,5) с резервированием рабочих позиций	Массовое	1—2	Не ограничено / 800 000	0,5—1,5	100 000—300 000	До 300	До 300	Возможна. Время остановки оборудования до 1 мес. (после окончания изготовления приспособлений, оснастки и шпиндельных коробок)	»	До 30 раз
АЛ из АС (среднее число АС—7,5) непереналаживаемые	Массовое	1	—	0,5—1,5	100 000—300 000	До 300	До 300	Не предусмотрена	»	До 30 раз

Key to table

1. Type of equipment
2. Multi-tool machine tools with numerically programmed control
3. Sectors (lines consisting of 5 - 6 multi-tool machine tools) controlled by computers
4. PAS and PAL (consisting of 1 -2 modules) with automatic replacement of spindle boxes *
5. Automatic production lines consisting of modular machine tools (average number of automatic production lines is 7.5) for the group processing of parts
6. Automatic production lines consisting of modular machine tools (average number of automatic production lines is 7.5) with the reservation of operating positions
7. Automatic production lines consisting of modular machine tools (average number of automatic production lines is 7.5) that are not resettable
8. Type of production
9. Unified and and small-scale production
10. Small and medium-scale production
11. Mdium-scale production
12. Large-scale series and mass produc tion
13. Mass production
14. Mass production
15. Number of model-sizes or modifications of parts to be processed
16. Within limits of technical characteristics of the machine tool
17. Up to 30
18. Minimum number of parts in batch (in the numerator) and the minimum number of parts of one designation to be processed (in the denominator)
19. Unlimited
20. Unlimited
21. Time for processing the part, in minutes
22. Annual output of parts, in numbers of items
23. Number of tools when working in the automatic cycle
24. Up to 250
25. Up to 800
26. Up to 300
27. Up to 300

28. Up to 300

29. Number of tools operating simultaneously

30. 15 – 35 (for PAS); up to 70 (for PAL)

31. Up to 250

32. Up to 300

33. Up to 300

34. Capability and time for resetting the equipment

35. When changing to processing of previously known parts

36. Possible. Time for stopping equipment is up to 1 - 2 hours when thee is previously prepared rigging with the use of USP [universal assembly attachment]

37. Possible. Time for stopping equipment is up to 3.5 hours (for preparing the sector)

38. Possible. Time for stopping equipment is up to 2 hours (for replacing the attachments and spindle boxes)

39. Possible. Time for stopping equipment is up to 30 minutes

40A. Possible. Time for stopping equipment is up to one month (following the manufacture of the attachments, rigging and spindle boxes)

40B. Not planned for

41. When changing to processing of new parts

42. Possible. Time for stopping equipment is up to 4 - 8 hours (for program checkout)

43. Possible. Time for stopping equipment is up to 48 hours (without considering time for preparing new programs and manufacturing of rigging, etc.)

44. Possible. Time for stopping of equipment is up to 20 hours (for replacing attachments and spindle boxes); for manufacturing new sets of spindle boxes and attachments requires 6 - 12 months

45. Not planned for

46. Raising labor productivity (as compared with processing on universal machine tools

47. 3.5-fold

48. 4.5-fold

49. Up to 15 - 20 times

50. Up to 25 times

51. Up to 30 times

52. Up to 30 times

* Some units and modules of PAS and PAL with the automatic replacement of multi-spindle boxes for raising productivity can be built into both sectors with multi-tool machine tools and automatic production lines for group processing.

Variable-Speed Drills

Moscow STANKI I INSTRUMENT in Russian No 3, Mar 80 pp 15-16

[Article by V. P. Balkov: "Variable-Speed Drills and Features of Their Use in Machine Tools with Numerically Programmed Control"]

[Text] The use of variable-speed drills on machine tools with numerically programmed control makes it possible to combine drilling and reaming, and in many cases to do away with preliminary centering, which result in a reduction of lost time for the auxilliary replacements of machine tool working parts and tools.

The most promising design for such drills with individual screw grooves for each speed, which makes it possible to remove the filings from each speed individually and perform more regrinding, has advantages over drills having a common screw groove for all speeds.

As a result of experimental research conducted at the All-Uion Scientific-Research Institute of Tool Building rules have been established for the process of making holes in parts of linkage with variable-speed drills with various design parameters and possibilities for improving designs,and the operational properties of these drills.

They tested drills with a diameter of d = 9 mm lesser and D = 14 mm greater speeds (the notation d/D is given) and a diameter of 11/17 mm with different thickness K of the center, angle w of the pitch of the screw groove and B of the blade at the greater speed, with an angle in a plane at a height of 2f = 118 degrees and 180 degrees respectively when drilling holes to a depth of 3.5 d and when reaming holes to a depth of 1D in steel 45 and in gray iron. The experiments were done on a vertical-drilling machine tool model 2R135F2, which was outfitted with a numerically programmed control device "Koordinata S-70-3".

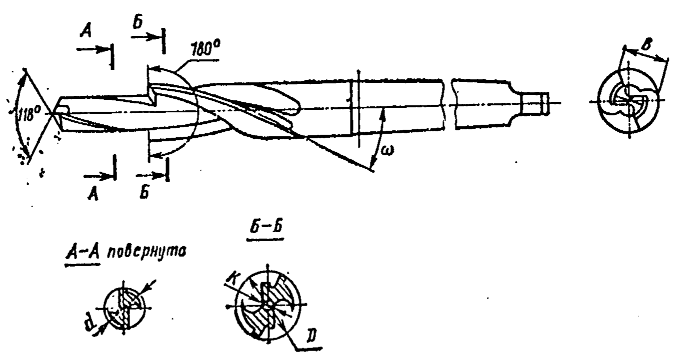
To maximize drilling conditions, reaming conditions and conditions for the combining of both fuctions with variable-speed drills for each kind of processing they selected the optimal cutting mode and when drilling - according to the diameter of the lesser speed and when reaming - according to the diameter of the greater speed of the drill. When transferring from drilling to reaming the cutting mode was changed automatically.

When developing improved designs of drills they used a method for planning the experiments. Here we see the factor levels viewed in different combinations.

Levels of factors	Upper	Lower
$w(x_1)$, in degrees	38	28
$K(x_2)$, in millimeters	2.6	1.6
$B(x_3)$, in millimeters	7.9	6.7

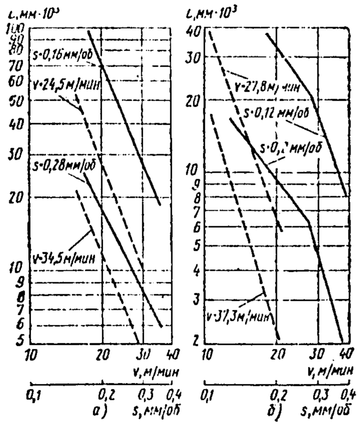
For the variable-speed drills ∅ 11/17 mm of steel R18 with the width of the lesser speed of 25 mm and with the gap of the working section of 95 mm the following testing conditions were chosen: cutting speed and feed at the lesser speed when drilling were 22.3 m/mm and 0.28 mm/revolutions respectively; at the greater speed when reaming these figures were 18.9 m/mm and 0.28 mm/ revolutions. A five-percent emulsion was used as a SOZH /lubricating and cooling liquid/; the material to be processed was steel 45.

The obtained equation of regression (based on durability tests) connected the durability of the drills (number of holes made) with the basic design parameters: $Y = 298 + 150.6X_1 + 76.9X_2 + 40.1X_3$. These data attest to the need to increase K, w and B within these limits. For the designs developed according to the results of the experiments see Drawing 1; the data for these drills are: w = 38 degrees; K = 0.24d mm; B = 0.44D ÷ 0.46D mm.



Drawing 1. Improved design for a variable-speed drill

The life of a variable-speed drill to a depth L of processing depends upon the cutting speed and feed at the lesser speed (Drawing 2a) is considerably greater than the life at the greater speed (Drawing 2b).



Drawing 2. Relationship of the durability of a drill at depth L of processing at lesser (a) and greater (b) speeds to the speed v of cutting (solid lines) and feed s (dotted lines).

The comparative durability tests (where v = 19.8 m/min and s = 0.23 mm/ revolutions) of the variable-speed drills (ø 9/14 mm) with these design parameters and geometric parameters, which are cited in Table 1, show that the durability of drills with a large convexity of the diametrical edge is 80 to 100 percent of the durability of drills with a normal screw point, obtained on a machine tool model 3653 by use of the two cams.

Table 1

Form of rear surface of the drill	Average value of durability (number of holes)	Average quadratic deviation of durability	Coefficient of variation in durability
Normal screw (ψ = 56 degrees, y = 50 degrees, f = 0.002d)	530	74	.14
Screw (ψ = 55 degrees, y = 31 degrees, f =.025d)	426	107	.26
Two-plane (ψ = 55 degrees, y = -57 degrees, f = .024d	522	92	.18
Two-plane (ψ = 54 degrees, y = -8 degrees, f = .02d)	461	97	.21

COMMENT: ψ is the angle of inclination of the diametrical edge of the drill; y is the forward angle on the diametrical edge of the drill; and f is the convexity of the diametrical edge.

The relationship of the precision of the holes upon the geometry of the diametrical edge of the drill was studied where v = 25.2 m/min and s = 0.28 mm/ revolutions at the lesser speed and v = 27.2 m/min and s = 0.2 mm/ revolutions at the greater speed of the drill. It was established the the relationship of the breakdown and the positioning deviation of the holes upon the method of sharpening drills is of a nature similar to what was determined previously *; however, because of the greater rigidity of the variable-speed drills the errors in the size and position of the holes are somewhat less than when processing with ordinary spiral drills.

In Table 2 it is clear that when processing with variable-speed drills with a rational design and geometry of the diametrical edge we get holes of 10 - 11 qualities with a positioning deviation of ± (0.025-0.1) mm.

The geometric parameters of the diametrical edge of the drill have a greater influence upon the precision of a smaller diameter than on the precision of a larger diameter hole, because when entering the work of the greater speed of the drill it does not have a support on the bands of the lesser speed, which significantly restricts the oscillations of the drill regardless of its geometry.

Table 2

Form of rear surface of the drill	Positioning deviation of the holes, mm	Breakdown of the holes, mm
Two-plane (ϕ = 55 degrees; y = - 58 degrees; f = .025d)	0.148/0.081	0.14/0.08
Two-plane (ϕ = 55 degrees; y = 0 degrees; f = .02d)	0.078/0.053	0.11/0.06
Two-plane (ϕ = 55 degrees; y = 0 degrees; f = .025d)	0.056/0.040	0.10/0.06
Screw (ϕ = 56 degrees; y = -36 degrees; f = .031d)	0.041/0.032	0.095/0.043

COMMENT: 1. The length of the lesser speed of the drill is 30 mm; the length of its working section is 90 mm. 2. In the numerator are given the values for the lesser diameter and in the denominator the values for the larger diameter hole.

* V. I. Balkov. Spiral drills for machine tools with programmed control. STANKI I INSTRUMENT, 1974, No 3, pp 9 - 10.

The experiments have shown that there is a linear correlation of the positioning deviation Y of the hole on the greater diameter upon the positioning deviation X on the smaller diameter of the hole. The coefficient of the correlation, estimated, for example, for conditions where v = 6.9 m/min at the lesser speed and 10 m/min at the greater speed and s = .16 mm/ revolutions, is .89, and the correlation ratio is .92. The equation of regression is Y = .75 X -.0366.

The productivity of processing the holes by variable-speed drills when programming cutting modes within the limits of one transfer in drilling and reaming can be determined based upon the structure of the basic time t_o of processing the holes. At a constant cutting mode $t_o = L/s_{min1}$ - the minute feed when drilling and reaming is set according to the diameter of the greater speed of the drill. When independently programming the cutting mode $t_o = (L - l)/ s_{min2} + l/s_{min1}$, where l is the depth of processing the smaller diameter hole; s_{min2} is the minute feed when drilling set according to the diameter of the lesser speed of the drill.

The achieved savings in basic time is $Dt_o = (L - l) X (s_{min2})/ (s_{min1}s_{min2})$.

The use of the variable-speed drills makes it possible to process on machine tools with numerically programmed control holes (on parts of securing) in basic design materials without preliminary centering with a positioning deviation of $\pm$ (0.025 - 0.1) mm and to increase productivity by 2 to 2.5-times.

Small-Scale, Series Production

Moscow STANKI I INSTRUMENT in Russian No 3, Mar 80 pp 25-27

/Article by Yu. P. Bashlayev and I. D. Volpyanskiy: "Analysis of the Structure of Parts Processed from Bars and Single Blanks in Small-Scale Series and Series Production"/

/Text/ Presently in the metal working industry nearly 65 percent of parts are manufactured in conditions of small-scale series and series production. Parts from bars are processed on universal lathes and turret lathes; and when group processing parts (when in comparatively large batches) cam single spindle automatic lathes are used.

The automation of lathe processing of parts from a bar in small-scale series production is possible by substituting universal lathes and turret lathes with cam single spindle automatic lathes with numerically programmed control.

To justify the need to create such machine tools and to determine their technological capabilities, the Leningrad Special Design Bureau of ARS /probably: automatic speed control/ analyzed the technological and design parameters of parts obtained when processing a bar on an automated lathe with numerically programmed control and on multi-spindle automated lathes.

Initial data was collected by studying enterprises having small-scale series and series production which use primarily universal metal-cutting machine tools. In assembling the initial data they took the following into consideration: any universal machine tool must have a field of rational application (the latter is characterized by the totality of the parts, which with consideration of the technological features of the performed operations and the series production nature are processed on a given machine tool with minimum expenditures); the technological capabilities of the newly planned automatic equipment with numerically programmed control, their technical characteristic, the selection of configuration decisions, the need to equip with additional devices to a large extent depend upon the technological and design parameters of the parts that are processed on them.

To study the field of rational application of universal machine tools they selected the random-sampling method, which consists of establishing generalized characteristics by studying only a portion of the component elements of the field - the parts and technological processes (initial data); the elements were selected so that they fully reflected the proportions and characteristic features of the field.

The reliability of the results obtained by this method is determined by the corresponding selection of sectors of industry, plants in each sector, the selection of parts, which make it possible to explain the basic laws of a given partial totality (sector). * Therefore, the initial data can be gathered in not all sectors of industry, but in those sectors in which the studied madine tools are used most extensively. The probability theory tells us that the laws, which characterized the entire field of application, can with adequate probability be established by processing information according to data of random selection in sufficient quantity. **

Initial data was gathered using the feature observations method, which consists of registering the parts that are processed on machine tools at the moment of studying the plant. This makes it possible to sufficiently objectively characterize the capacity of a machine tool to process parts with certain criteria.

Information for the technological justification of the need to create automated lathes with numerically programmed control was gathered in the field of the rational use of such machine tools, i. e., at enterprises of various sectors of industry, in which a batch of parts are processed in the course of .25 to 10 work shifts (small-scale series and series production) on lathes and on turret lathes with manual and automated control and on cam automatic lathes.

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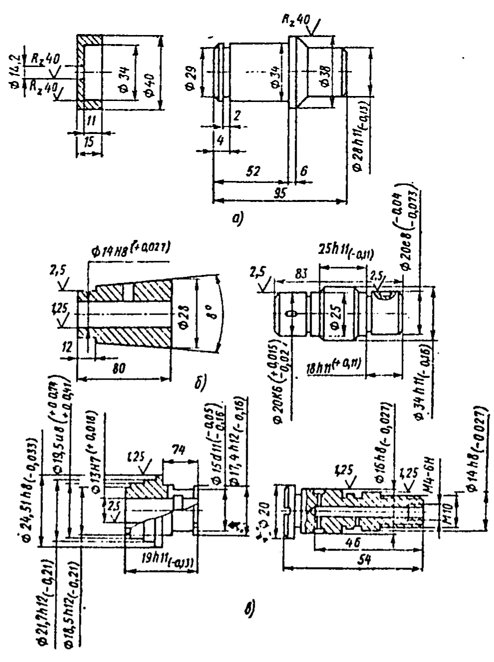
* A. O. Etin and B. L. Shumyatskiy. Fields for the use of lathes. Moscow, NIImash, 1970, Series S -XII, p 112.

** Temporary instruction for determining comparative productivity and efficiency of machine tools. Moscow, ENIMS, 1972, p 106.

They took six sectors of industry, which have a large park of lathes and turret lathes, as objects for study. They chose 4 - 5 plants in each of these branches which have the largest park of the equipment to be studied. In this manner they studied 29 enterprises. The assembled initial data embraced the processing of eight groups of parts (290 - 490 items in each group): from bars with a diameter of 16, 25, 40 and 65 mm and from single blanks with a diameter of 80, 100, 125 and 160 mm; the total number of studied parts can to 2,450 (from a bar) and 850 (from single blanks).

Analysis of the design of the processed parts, which was performed earlier in the Leningrad Special Design Bureau of ARS, showed that in the general sample the greatest amount of time for loading equipment is spent on processing parts of a simple configuration. However, the use of only such parts as representatives for the analysis of the efficiency of processing on automated lathes with numerically programmed control sharply reduces the savings from adopting these automated equipments and does not make it possible to correctly reflect their technological capabilities. Therefore, following the assembly of the initial data all parts obtained from a bar and from single blanks were broken down into their design and technological features as simple, medium complex and complex parts (Drawing 1) (classification was made only for those surfaces that are processed at the present time on lathes).



Drawing 1. Examples of simple (a), medium compex (b) and complex (c) parts.

Simple parts have a total number of exterior and interior surfaces of no more than four (facets and grooves are not taken into consideration); they do not have threaded sections or curved surfaces; and processing precision corresponds to 11, 12 and 14 qualities.

Medium complex parts have a total of five exterior and interior surfaces; one curved surface or one threaded section (or none); and processing precision corresponds to 6, 7 and 8 qualities.

Complex parts have a total of six or more exterior and interior surfaces, no less than one curved surface and no less than one threaded section (or none); and processing precision is 6, 7 and 8 qualities.

The information obtained from the plants was encoded in accordance with a specially developed system and transferred on to punched cards for further processing on a computer. This article cites some of the results of the analysis of the parts obtained from a bar (maximum processed diameter was $D \leqslant 40$ mm) and from single blands ($D \leqslant 125$ mm). The results of the analysis are reflected in the relative labor intensiveness, which is the ratio of labor intensiveness for processing parts with the analyzed criterion to the total labor intensiveness for processing the examined body of parts.

Below we see the rlative labor intensiveness for processing various parts obtained from a bar. The labor intensiveness of processing 390 parts (165 simple, 158 medium complex and 67 complex parts) was determined.

Parts	Relative labor intensiveness, in percent
Simple	30
Medium complex	51
Complex	19
With hole	70 - 73
With hole and exterior threading	21
With hole and interior threading	24
Without hole with exterior threading	9

The work that was done showed that the loading of the equipment for processing of parts with cylindrical and curved surfaces is insignificant; the relative labor intensiveness of processing parts with a beveled surface is only 5 percent; the relative labor intensiveness of manufacturing parts with a hole to a precision of 7 qualities is 22 percent, to a precision of 9 qualities 18 percent, and to a precision of 11 qualities 14 percent, and to accuracies of 12 and 14 qualities 46 percent.

Statistical weightings of the loading time for the studied machine tools showed that for simple parts up to 75 percent of the time is used for processing with an average per-item time $t_{sht.sr} \leqslant 3$ minutes, for medium complex parts up to 75 percent of loading time is used for processing with $t_{sht.sr} \leqslant 3.5$ minutes, and for complex parts up to 80 percent of the time is used for processing with $t_{sht.sr} \leqslant 4$ minutes.

When carrying out this work they also determined the labor intensiveness of operations that are not now performed on lathes, such as the milling of various surfaces situated from different sides of a part, the drilling of holes found on these surfaces, and threading. Such operations are conditionally called finishing operations. Below we see some results of analyzing these operations (relative labor intensiveness is the ration of labor intensiveness of the studied finishing operation to the total labor intensiveness of lathe processing) on parts obtained from a bar with a diameter of 16 - 65 mm.

The relative labor intensiveness of processing parts, which require finishing operations from the side of the forward face and from the side of cylindrical surfaces, was 20 - 25 percent. Moreover the relative labor intensiveness of processing parts requiring finishing operations from the side of the forward face was 4 - 5 percent and 9 - 10 percent for the automated equipment intended for processing a bar with a diameter up to 40 and 65 mm respectively. The remaining relative labor intensiveness is used for processing parts requiring operations in a plane perpindicular to the axis of the part.

Analysis of the positioning of surfaces requiring additional drilling following lathe processing and additional milling and other operations following lathe processing showed that in all groups of complexity of parts when processing a bar with a diameter up to 40 mm the relative labor intensiveness of processing parts with a positioning of such surfaces at an angle to each other does not exceed 1 - 2 percent; i.e., as a rule, the surfaces requireing finishing operations are in one plane.

The relative labor intensiveness of processing parts which require two finishing operations in one plane passing through the axis of the part is 5.5 percent. Analysis of the labor intensiveness of processing parts requiring finishing operations from the side of the forward face showed that the maximum equipment loading is used for parts which (from the side of the forward face) are milled and drilled, and with a diameter of the bar at 65 mm they make holes (thread and expand) in them.

Analysis of the labor intensiveness of processing parts requiring finishing operations on a cylindrical surface showed that the maximum relative labor intensiveness is carried by parts that require the drilling of holes and the milling of grooves and flattened spots that are perpindicular to the axis of the part and parallel to this axis. The relative labor intensiveness of processing parts with threaded holes drilled in cylindrical surfaces is not great (when manufacturing such parts from a bar with a diameter of 65 mm the relative labor intensiveness of processing them rises significantly).

Analysis of parts obtained from single blanks with D = 80 ÷ 125 mm, showed that almost 100 percent of labor intensiveness of processing goes for parts having a center hole; moreover, nearly 5 percent is used for processing parts with exterior surfaces and nearly 12 percent for parts with interior surfaces. The relative labor intensiveness of parts having beveled surfaces is 11.5 percent, curved surfaces - 2 percent, holes with a precision of 7 qualities - 41 percent, a precision of 9 qualities - 29 percent, a precision of 11 qualities - 10 percent, and a precision of 12 and 14 qualities- 20 percent. In this manner, the equipment loading for processing precise surfaces (of 7 and 9 qualities) is almost 70 percent of the total equipment loading.

The performed analysis of parts manufactured from a bar and from single blanks shows that in parts with D > 40 mm it is mandatory to have a center hole, i.e., the relative labor intensiveness of processing such parts is 100 percent and the relative labor intensiveness of processing parts with threaded surfaces decreases (as compared with the relative labor intensiveness of processing such parts with a diameter up to 40 mm). When manufacturing parts from single blanks the relative labor intensiveness of processing parts with beveled surfaces and precise (at 6, 7 and 8 qualities) holes is greater that when manufacturing parts from a bar.

Analysis of the operations of processing parts from single blanks showed that the relative labor intensiveness of finishing operations is approximately 60 percent, of which 26 percent goes for parts that are processed from the side of the forward face and 34 percent for the parts, which are processed from the side of the cylindrical surface. The relative labor intensiveness of parts (manufactured from single blanks), which require finishing operations on surfaces at an angle to each other, is greater than the relative labor intensiveness of processing such parts that are manufactured from a bar. Moreover, whereas the relative labor intensiveness of parts requiring finishing operations from the side of the cylindrical surface is only 3 - 6 percent, the relative labor intensiveness of parts requiring finishing operations from the side of the forward face reaches 30 to 35 percent. The maximum relative labor intensiveness of processing is required by parts having surfaces requiring finishing operations at angles divisible by 30 degrees.

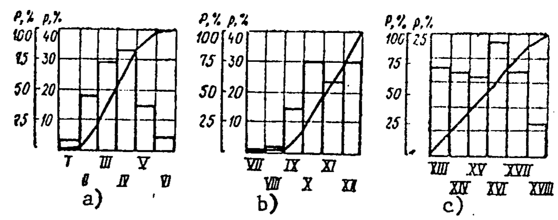
The relative labor intensiveness of processing parts requiring two finishing operations in one plane passing through the axis of a part is 9 percent, while the relative labor intensiveness of parts requiring three finishing operations is 1 percent.

In carrying out a finishing processing from the side of the forward face 1.5 percent of the relative labor intensiveness is used for milling, 19 percent for drilling and 5.5 percent for forming threaded holes situated eccentric to the axis of the part.

On finishing operations from the side of the cylindrical surface 12 percent of labor intensiveness goes for drilling, 1 percent for the milling by a disk cutter perpindicular to the axis of the part, 1 percent for the milling by a tail cutter parallel to the axis of the part, 4 percent for the milling by the tail cutter perpindicular to the axis of the part, and 14 percent for making threaded holes.

Analysis of the data obtained from the studied enterprises makes it possible to examine the structure of the loading of machine tools for the processing of different batches of parts. The limits of the boundary values of the parameters of a batch of parts were selected in a way that one could characterize the loading of machine tools for the processing of one batch in the course of .25 - 1, 1 -3 and 6 - 10 work shifts. Such a classification corresponds to small-scale series production and the upper and lower limits of series production.

Drawing 2 shows the laws of distribution (in the studied sectors of industry) of batches of parts with a different number of parts in them, the labor intensiveness of processing batches with a different number of parts and the annual programs. As can be seen (See Drawing 2b), nearly 47.4 percent of labor intensiveness of processing goes for manufacturing parts in batches up to 500 items, nearly 70 percent in batches up to 1,000 items. The data of distribution of volumes of annual program (See Drawing 2c) make it possible to note that for approximately 75 percent of part designators the annual program is 2,500 to 6,000 items. When there is a monthly output the batch amount will be 200 to 500 items, i.e., fall within the boundaries of series production.



Drawing 2. Laws of distribution of batches of parts with a different number of parts in them (a), labor intensiveness of processing batchs with a different number of parts (b), and annual programs (c) (number of parts in a batch: I - up to 20; II - up to 50; III - up to 200; IV - up to 500; V - up to 1,000; VI - up to 2,000; labor intensiveness of processing when the number of parts in the batch is: VII - up to 20; VIII - up 50; IX - up to 200; X - up to 500; XI - up to 1,000; XII - up to 2,000; annual program in items: XIII - up to 100; XIV - from 100 to 250; XV - from 250 to 600; XVI - from 600 to 2,500; XVII - from 2,500 to 6,000; XVIII - from 6,000 to 12,000; p - relative frequency; P - acquired relative frequency.

The research that was done is part of the comprehensive work being done by the Leningrad Special Design Bureau of ARS to analyze the design and technological parameters of parts subject to processing on planned automatic single-spindle lathes with numerically programmed control. The obtained data will make it possible to more objectively approach the problem of designing individual units of the machine tools, of determining the compositions of cutting and auxilliary tools, configuration decisions and other aspects of planning and designing machine tools.

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