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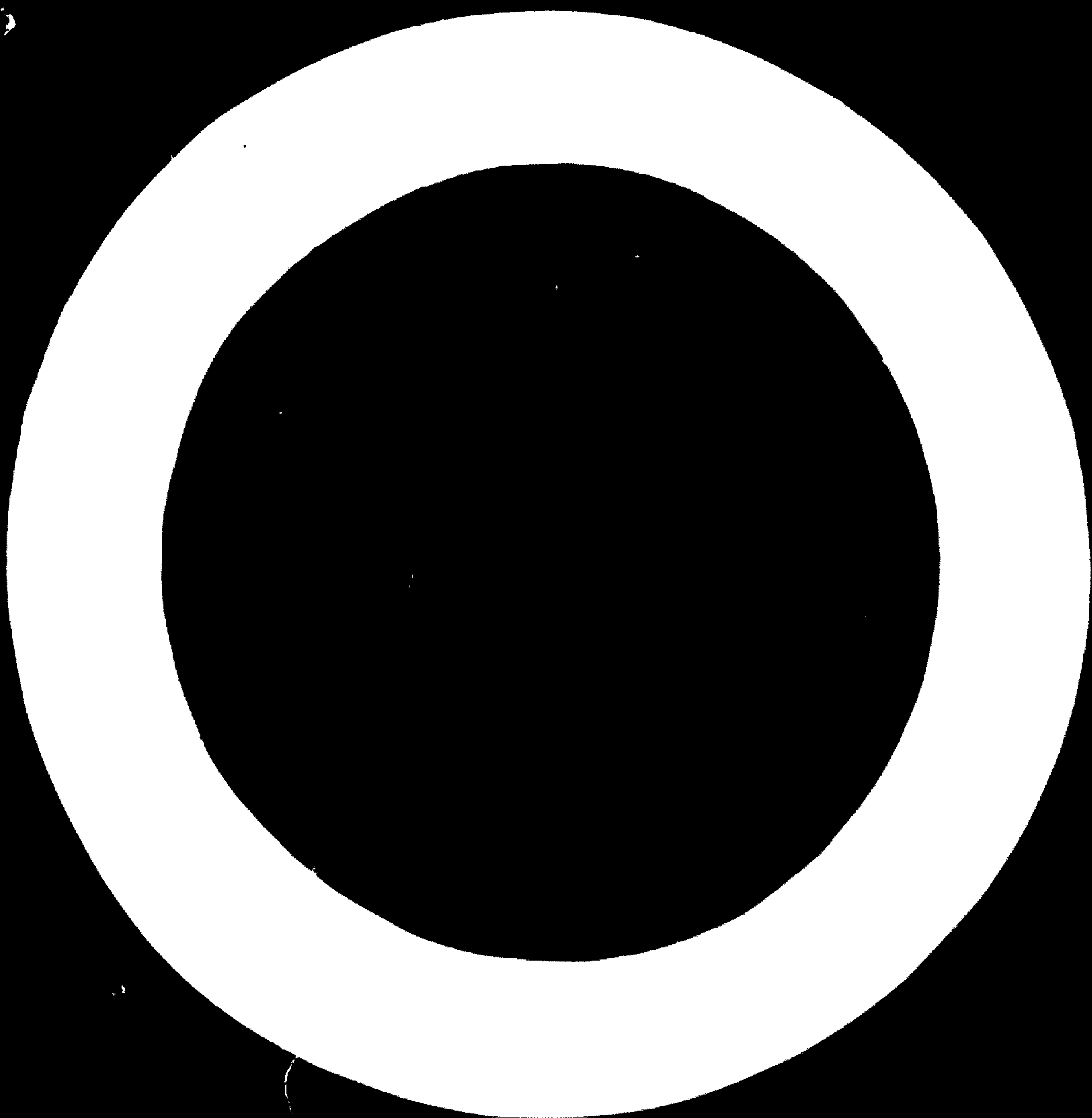

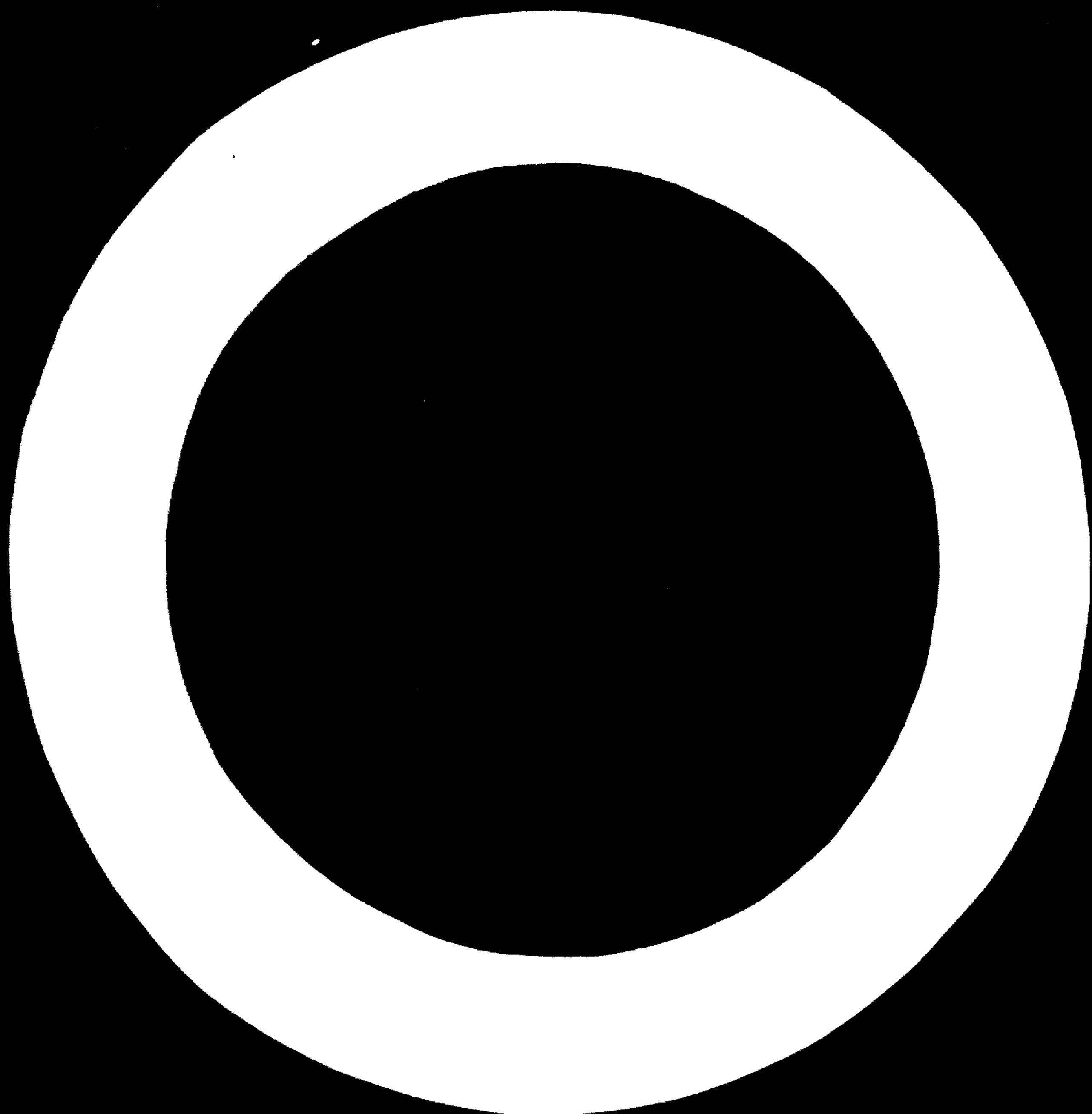

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MASS PRODUCTION METHODS IN THE MACHINE-TOOL INDUSTRY IN THE UNION OF SOVIET SOCIALIST REPUBLICS

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INTRODUCTION

The Krasny Proletary machine-tool works is one of the oldest industrial enterprises in the Union of Soviet Socialist Republics. The works is more than 100 years old. For over fifty years, machine tools have been on the works' production programme. The Krasny Proletary works is currently specializing in the production of metalworking lathes and is a major machine-tool manufacturer in the Soviet Union.

The 14,000 machine tools turned out annually place the works in the forefront of machine-tool manufacturers, not only in the Soviet Union, but also throughout the world. The huge volume of production indicates that the works' production is characterized by large series.

The planned specialization in the USSR has made it possible to concentrate the production of a single type and size of an engine (universal) lathe (200–215 mm in centre height) at an out-works.

This created conditions which were conducive to a substantial increase in production series and to the introduction of mass production methods, first of all, to turn to account the highly efficient technology and production techniques developed by motor-car and tractor manufacturers.

The Krasny Proletary works has thus become a pioneer in the introduction of mass production methods in the machine-tool industry.

I. DEVELOPMENT OF PRODUCTION LINES

As early as 1944, the works was the first in the world machine-tool industry to install a production line for the assembly of lathes, model 1D62 (DIP 20). Then in 1945, a modernized lathe, model 1D62 (DIP 20) was put on the production line in the mechanical and assembly departments. The subsequent years saw further work in the development and improvement of production-line methods in machine-tool building until, in 1949, model 1A62 lathes were put on the production line in the entire mechanical-assembly cycle.

In 1956–1957, production lines at the works were completely rebuilt as part of the routine reconstruction of large-series production departments and the change-over to a new lathe, model 1K62.

Later, additional steps were taken for the mechanization of all production lines in lathe manufacture at all main departments. At the current time, in large-series production departments, there are sixty production lines in operation; the conveyors in service attain 1,300 metres in length; rolling-tables total 2,000 metres in length; there are 200 units of hoisting and transportation equipment and over 10,000 varieties of technological fixtures.

The experience in production-line methods which has been accumulated by the works over the years is quite considerable. The engineering and technical staff, production engineers and designers of fixtures and mechanization facilities have contributed greatly to the solution of problems involved in setting up a production line system.

It is no wonder, therefore, that the works' experience is continuously explored and drawn upon by the machine-tool industry, as well as by other machine-building enterprises in the Soviet Union and other centrally planned economies.

It is worth noting that the Krasny Proletary works rendered help to mainland China in setting up the mass production of lathes in 1956–1957.

In 1962, the Colchester, in the United Kingdom of Great Britain and Northern Ireland, was the first among the manufacturers in free-enterprise economies to introduce production-line methods in machine-tool manufacture.

During the past twenty years, every machine-building industry, including machine-tool production, has accumulated enormous experience in production-line methods and the literature on the subject is extremely rich; it seems, therefore, superfluous to dwell on basic concepts and general statements relating to mass production.

It is worth while, however, to draw some conclusions on the essential features of production-line methods as applied at the Krasny Proletary plant. The work for setting up mass production had the following objectives at every stage: (*a*) a sharp reduction in labour consumption and, consequently, an increase in labour productivity and a decrease in production costs; (*b*) to raise substantially the output of machine tools at the same or insignificantly expanded production areas; and (*c*) to curtail essentially the manufacturing cycle.

At every stage of the work for setting up mass production, and such stages were, as a rule, connected with a change-over to the manufacture of some new machine-tool models without stopping the production of those introduced earlier, the works' personnel successfully coped with the above-mentioned targets.

This is borne out by the following figures. In the years since a change-over to production line methods, the output of machine tools has increased more than twice and labour consumption has diminished by 72 per cent, although the growth of production areas was as insignificant as 8 per cent.

Summing up the many years of experience in setting up mass production, one may safely state that the principal factors involved were: highly efficient technology; group production and group-finishing methods; and a complex solution of all the problems involved, covering the entire production cycle and introducing mechanization into principal and auxiliary operations.

Undoubtedly, one of the principal factors in the work was the effort to achieve maximum product quality.

A. *Highly efficient technology*

Even prior to beginning the work for a change-over to mass production, steps had been taken to introduce the highly efficient production methods evolved in the motor-car and tractor industry into the serial production of machine tools, particularly the special-purpose equipment used to finish machine-body components. Further work for setting up mass production permitted the elements of highly effective technology to be introduced with even greater success. Of course, the methods typical of mass production had to be adapted to suit the conditions of serial production.

Success in the solution of technological problems was mainly due to the perfection of machine-tool designs in those aspects, account being taken of every stage in component manufacture and in the assembly of separate machine units and of the machine tool as a whole. This proved to be a crucial factor.

Therefore, production engineers at Krasny Proletary give much thought to the technological aspects of a new design as a part of the preparations for its serial manufacture on the production line. In the process of developing an experimental model or an experimental batch, great consideration is given to perfecting the design, with many improvements usually being made in both the design and the technological features of the new machine tool.

Thorough work on the technological features of the 1K62-machine tool (see figure 1) permitted, first of all, the use of advanced methods in the production of blanks, usually known as component-forming methods. In other words, steps were taken to obtain blanks with minimum allowances or to shape them so as to bring them as close as possible to finished components.

Modern technology has enormous potentialities in this respect. Over 50 per cent of all the components at the plant are currently manufactured with the use of advanced shaping methods.

Along with conventional grey and malleable cast-iron castings produced from patterns made of metal, the works is using precision casting under pressure and to cast patterns, as well as core casting. Conversion of ten items to this type of casting permits the plant to save 4.7 kg of cast-iron per machine tool and brings down labour consumption by 30 minutes.

Pressure casting of zinc alloys is used to obtain sixteen items of machine components, e.g., panels, boxes, rings, joints etc. As a result, metal consumption goes down three times and labour consumption two times, on the average.

The casting to cast patterns is used to obtain thirty-five components ranging in weight from 30 grams to 2.5 kilogrammes: discs, rockers, planks, forks etc. This permits the reduction of mechanical processing by as much as 85–90 per cent and saves 28 kg of metal per machine tool.

The lack of an adequate centralized system for the delivery of precision castings interferes with the even wider application of this highly effective casting method.

The works has no foundry department of its own, and for this reason, the technological aspects are worked out in co-operation with casting suppliers.

Hot stamping on power forging presses, stamping hammer and horizontal forging machines yields 100 items of components: gears, handles, rings and spindles ranging in weight from 100 grams to 57 kilogrammes.

This is the reason that mechanical departments obtain blanks with allowances as low as within 1.5 mm on either side.

A widely applied procedure in the semi-finished products department is the cutting of blanks on presses prior to stamping. For diameters of 100–200 mm, the cutting is conducted, lest cracks should appear, with heating in a special mechanized gas-furnace attached to the press.

Much attention has been paid at the works to the introduction of stamped and stamp-welded sheet structures. By this method, 275 items are produced from sheet metal of 1.5–3 mm thickness and varying in weight from 15 grams to 33 kilogrammes. The Krasny Proletary plant was the first among machine-tool manufacturers to introduce large-size fully-stamped parts (troughs, trays etc.) and to use deep extrusion in the cold stamping of housings, shells etc. (up to 175 mm deep). Recently, new efforts have been made to expand the application of sheet components, and cast-iron parts have been converted to sheet stamping to some extent. Although this has involved a radical change in design, the effect has been very substantial. For instance, in converting the gear-box cover in the 1K62 machine tool from cast-iron to sheet stamping, the economy achieved was as high as 33 kg,

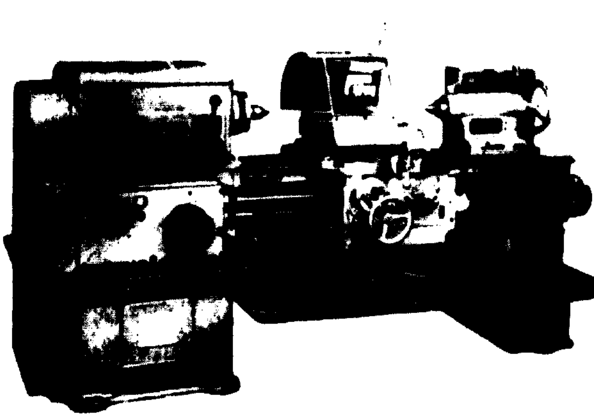
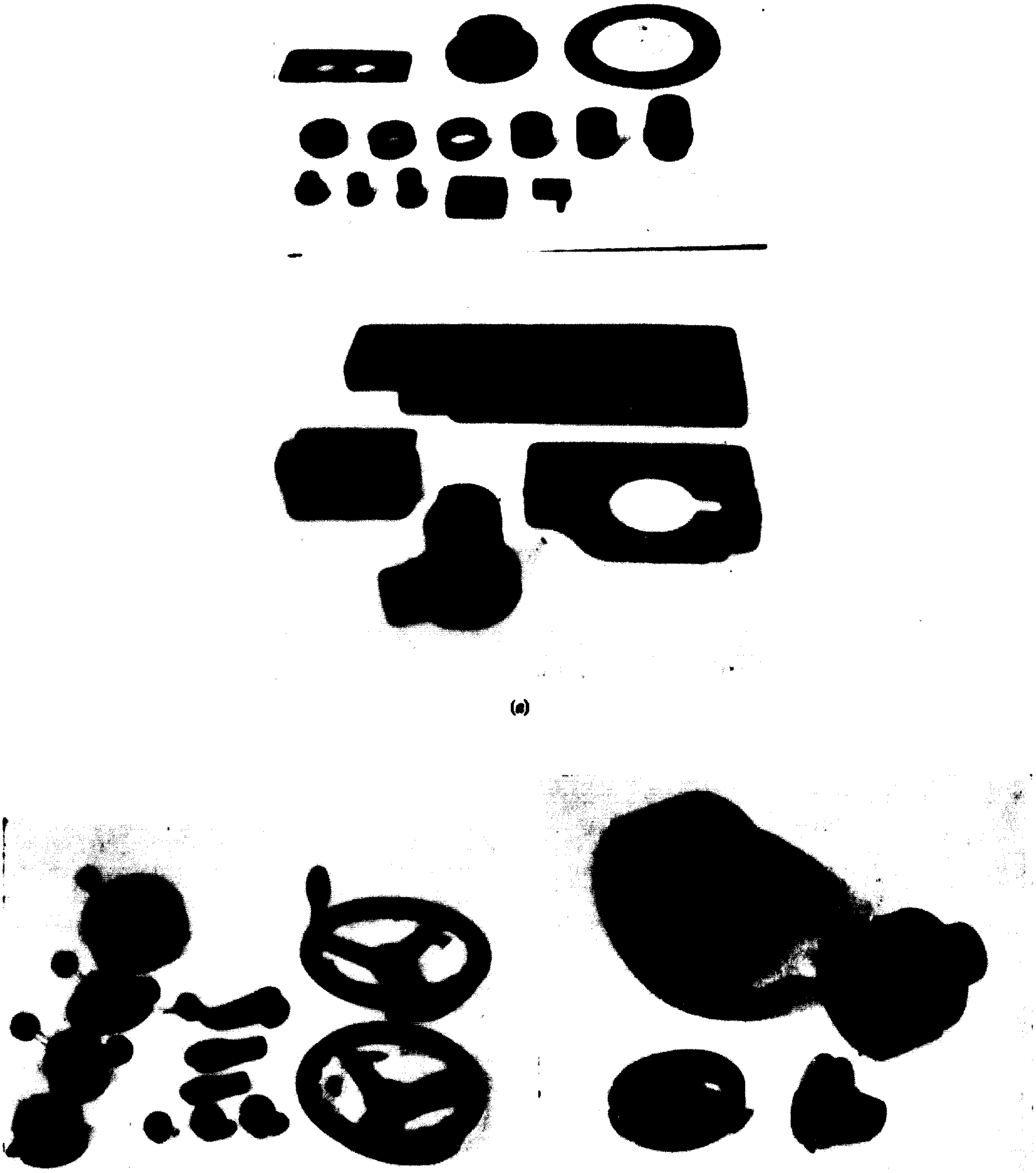


Figure 1
TYPE 1K62 THREAD-CUTTING LATHE



(a)

(b) (c)

Figure 2

PLASTIC MEMBERS USED IN TYPE 1K62 THREAD-CUTTING LATHE and in converting the minor submotor plate, as high as 1.3 kg.

In collaboration with the Stankoagregat works, where centralized stamping-welding production is being set up, the Krasny Proletary works is engaged in experimental work on a welded bed for the 1K62 lathe. Compared with the cast-iron bed, it weighs 300 kg less.

In the past seven years, every effort has been made to introduce components from polymeric materials. Such materials as phenoplast, fibre-filled moulding material, capron and polystyrene go into the manufacture of fifty-five components for the 1K62 machine tool (see fig. 2). This trend is going to continue. Apart from their use in various control components (handles, knobs etc.) and lubrication devices (oil indicators, plugs etc.), plastics are used in the manufacture of loaded components (pulleys, covers, levers etc.). Experience has shown that plastics are highly effective with the works' scope of production. The reduction in component weight amounts to 70–90 per cent and in production costs, to 20–70 per cent. Every year as much as 1,100 tons of metal and over 150,000 roubles are saved by the plant.

It should be noted that, thus far, the introduction of plastic components is a rather complicated process. In the conversion to plastics, it is not possible merely to reproduce the shape of the former metallic component; further design work is needed. Such work is usually undertaken by the plant in co-operation with the specialized supplier enterprises. To produce plastic components, complicated press-moulds are needed. This explains why the process of putting into service plastic components takes quite a long time. Before being put into serial production, plastic components, taking account of the novelty of the material, must be subjected to prolonged laboratory and workshop tests. Therefore, the introduction of plastic components is undertaken in collaboration with various research institutions (All-Union Research Institute for Plastics, Experimental Research Institute of Metal-cutting Machines (ENIMS) etc.).

There are available numerous new plastics with highly valuable properties, in so far as machine tool building goes (fibreglass plastics, polypropylene, polyethylene etc.). However, they are still too expensive to have much effect.

Meanwhile, profile-rolled stock, for instance, could be effectively applied in the plant's serial production. With such components as cutter-holders, racks, splined shafts etc. converted to profile rolling, the economy of metal at the works could be as high as over 300 tons per annum.

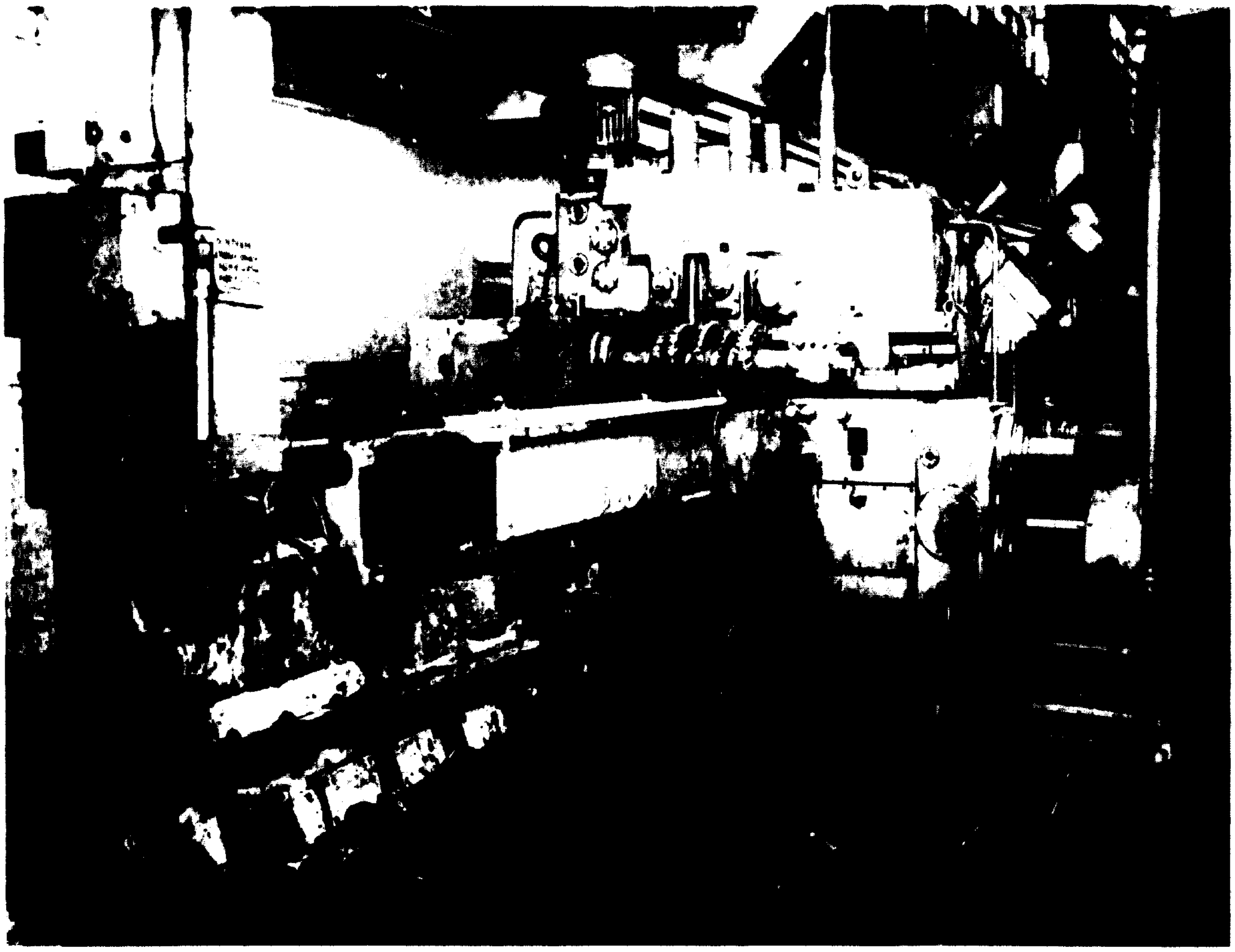


Figure 3

NINE-SPINDLE MILLING MACHINE FOR MACHINING TYPE 1K62 LATHE BEARINGS: VIEW ONE

A highly efficient machining technology cannot be achieved unless high-capacity equipment, such as special-purpose and unit-type machine tools, are put to use. They permit the maximum concentration of machining processes, the use of multiple-spindle and multiple-cutter tools and the introduction of automatic cycles, and make it possible for several machine tools to be attended by a single worker.

Machining of plane surfaces in the mechanical department is mainly coped with now by milling, instead of planing, and by grinding, instead of milling. Illustrations of such high-capacity concentrated surface-machining may be found in figures 3 and 4, which show the special-purpose nine-spindle machine tools GEFS, models GF479 and GF480, which perform roughing and semi-finishing operations of the type 1K62 machine-tool bed. Each of them is equipped with seventeen hard-alloy milling-cutters so that their efficiency is three to four times higher than that of planing. The machine set up with this number of cutters is shown in figure 5.

The milling of feed-boxes on six sides is carried out on a four-spindle longitudinal milling machine set up for combining three operations with the use of a six-seat hydraulic fixture. By changing the position of components in this fixture, one pass of the machine-table results in two feed-boxes being milled on six sides. Similarly, a hydraulically clamped multiple-seat fixture is used on a four-spindle milling machine for the apron-body surfaces to be machined (see fig. 6).

The concentration of operations is particularly great in boring and drilling of type 1K62 machine-tool body components: speed-box, apron, feed-box etc.

The speed-box body is subject to boring and drilling on six unit-type machines with the number of spindles varying from twenty-one to fifty-two, using hard-alloy multiple-edge combination tools.

The simultaneous application of twenty to thirty cutting tools, for instance, has permitted a reduction of 12–15 minutes in the labour required for longitudinal boring.

The apron body is machined on four machine tools having a total of 206 spindles (see figs. 7, 8 and 9), and the feed-box on three machines with a total of 147 spindles.

These are all semi-automatic machines with machining times varying between 6 and 12 minutes, so that several

Figure 4

NINE-SPINDLE MILLING MACHINE FOR MACHINING TYPE 1K62 LATHE BEARINGS: VIEW TWO

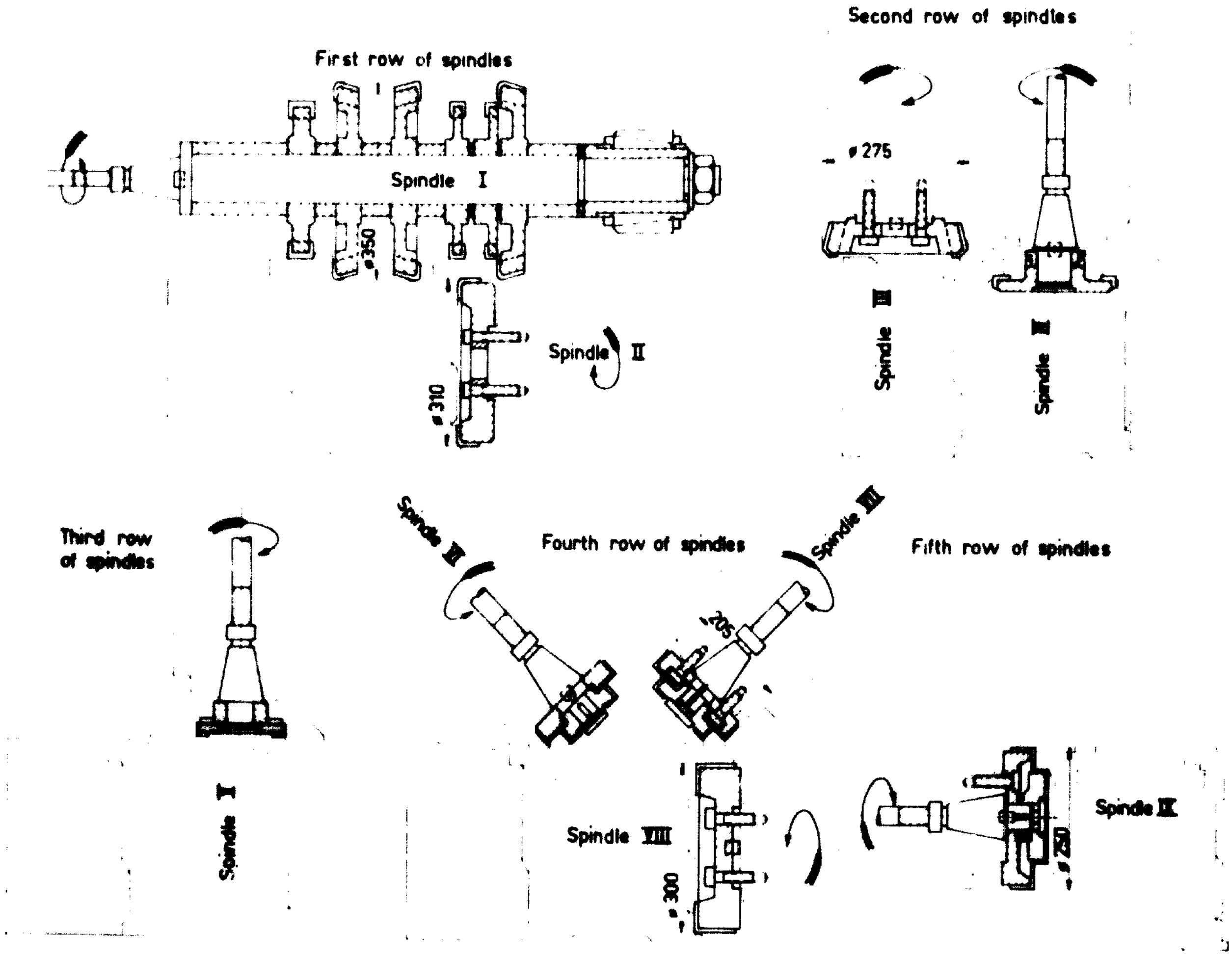


Figure 5

TOOLING DIAGRAM OF A NINE-SPINDLE HORIZONTAL PLANO-MILLING MACHINE FOR SEMI-FINISHED MILLING LATHE BEARINGS

machines can be entrusted to one person. The worker is responsible for loading and unloading the machine tool with the aid of individual hoists, for starting the machine and for keeping a check on the performance of the mechanisms and cutting tools.

This equipment has permitted labour consumption to be reduced by 50 per cent, compared with previous methods. It pays off within two to three years.

The turning processes are mainly handled by copying, multiple-cutter, multiple-spindle horizontal and vertical semi-automatic and fully automatic lathes using power clamps and gang set-ups.

Altogether, special-purpose machines account for 30 per cent of the total number of machine tools. The balance is universal equipment relying on such special fixtures as clamping chucks, jigs, drill heads, milling and other attachments, etc.

Thus, highly efficient technology is impossible without a great number of special technological fixtures. The number of fixtures (including mandrels), dies and press-moulds for the 1K62 machine tool totals 5,000 articles, i.e., the equipment factor in this group of fixtures is as high as six. The cutting, auxiliary and measuring tools and instruments used in connexion with the 1K62 machine also amount to over 5,000 items.

These fixtures are characterized by high reliability securing the required accuracy in operation at high speeds and feeds, in both single-seat and multiple-seat attachments. Mechanization of workpiece clamping sharply reduces the time consumption and makes for easier manual effort.

The production engineers and fixture designers have devoted much energy to developing highly efficient fixtures with advanced clamping elements: pneumatic, hydraulic, electromechanical and pneumatic-hydraulic.

Pneumatic clamps are finding a particularly wide application on lathes and multiple-cutter machines, while pneumatic-hydraulic clamps are used on milling, drilling and other machine tools equipped with single-seat and multiple fixtures.

A standard design of the piston type (pump-free) of pneumo-hydraulic amplifier (see figure 10) has been developed by the works' engineers and is now used in fixture design. Many years of experience in using fixtures in combination with such amplifiers have shown them to be highly dependable, and they are rarely in need of repair. A hydraulic amplifier of this type with an amplification ratio as high as 25, in the case of 4–5 atm of air pressure, will be used for a preliminary clamping at 4–5 atm and ultimate reliable clamping of up to 100–125 atm.

The application of hydraulic amplifiers has made it

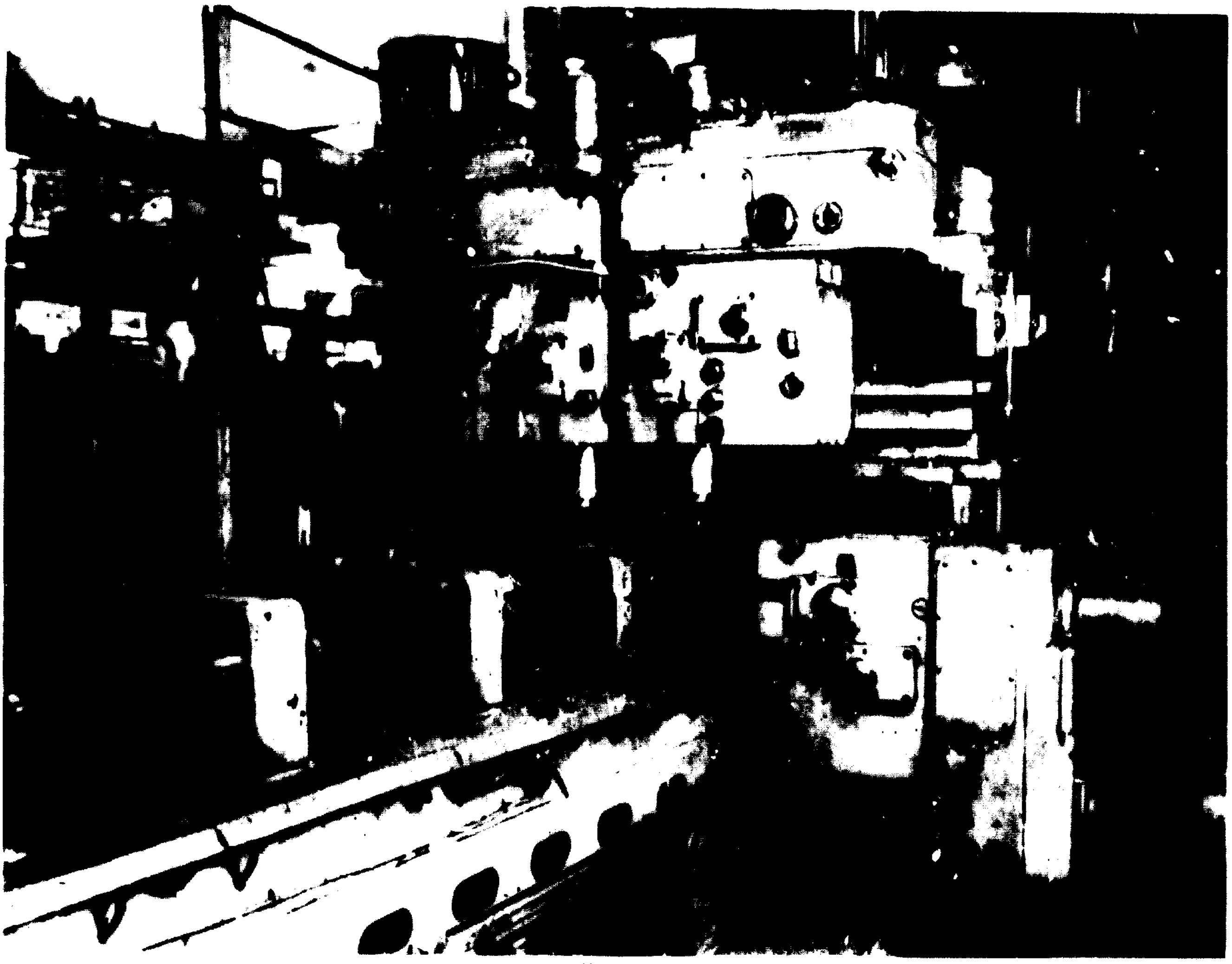


Figure 6

MILLING MACHINE FOR MACHINING TYPE 1K62 LATHE APRON PLANES

possible to reduce the auxiliary time in workpiece clamping, in such operations as machine-bed and tailstock machining or feed-box milling, to 3–5 seconds instead of the 2–5 minutes previously required (see figures 11 and 12).

Special-purpose cutting tools (for use at either special-purpose or universal machine tools) are usually manufactured by the works as combination, multiple-edge, hard-alloy tipped pieces. Among them are drills, countersinks and reamers.

Threading on the unit type of machine tools is effected through the use of high-speed tapping set-ups. The chip-forming groove on the hard-alloy lathe cutters is produced by the electro-erosion technique. Incidentally, the electro-erosion set-up is successfully applied also where machine-body components are manufactured for the remnants of tools (drills, taps), if ruptured, to be burnt out from the components' holes.

Production line methods demand that inspection and measurement procedures be on a high level and that high-quality measuring fixtures be available. In the manufacture of the 1K62 machine tool, as many as 2,500 special measuring devices, among them over 300 items of inspection set-ups and gauges, are used.

Recently, various appliances for active control have increasingly been used in grinding and honing jobs.

A highly efficient technology presupposes a large-scale mechanization of manual labour.

In the assembly shop, the assemblers' work-stations on the production lines for unit and general assembly of the 1K62 type of machine tools are provided with diversified mechanical fitters' tools, such as nut runners, screw runners and threaders, as well as pneumatic-hydraulic pressing appliances. For sleeves to be pressed into unit bodies, special stationary pneumatic-hydraulic fixtures have been developed (see figure 13), while suspension hydraulic-brackets are useful to have shafts, spindles and flanges pressed in (see figure 14).

The works' engineers have long been working on the problem of introducing grinding as a substitute for scraping. Tailstock slides and, partly, carriages have been converted to grinding in place of manual scraping. As a result, scraping time has been reduced at least by two hours. A new development in this field is that the grinding machines which are used in place of scraping are set up directly in assembly lines.

Electric panels for the 1K62 type of lathe are currently delivered by a specialized electrical enterprise. Earlier,

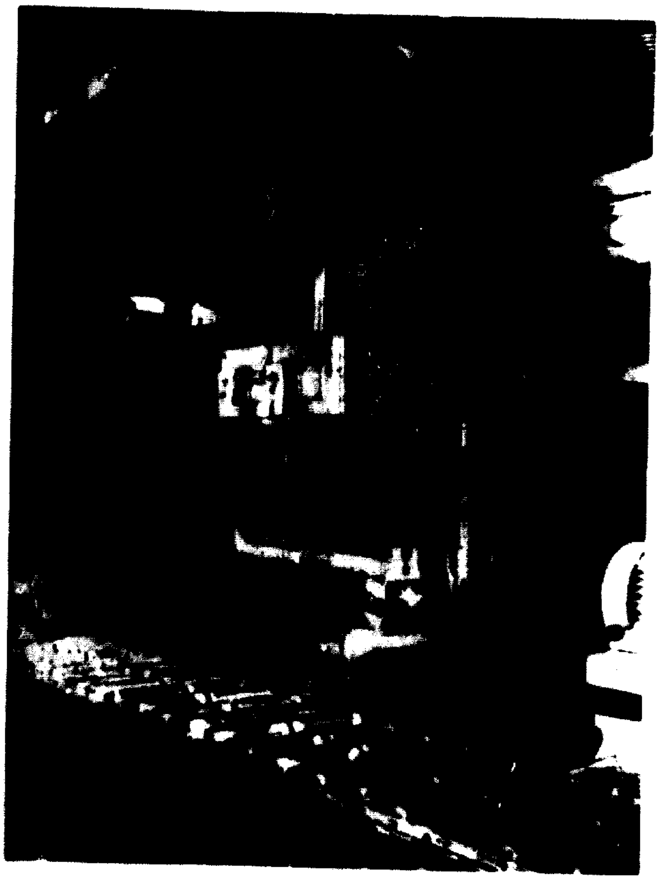


Figure 7

PLANT UNIT MACHINE FOR TRANSVERSELY MACHINING TYPE 1K62 LATHE APRON HOLES

Figure 8

PLANT UNIT MACHINE FOR LONGITUDINALLY MACHINING APRON HOLES FOR TYPE 1K62 LATHE

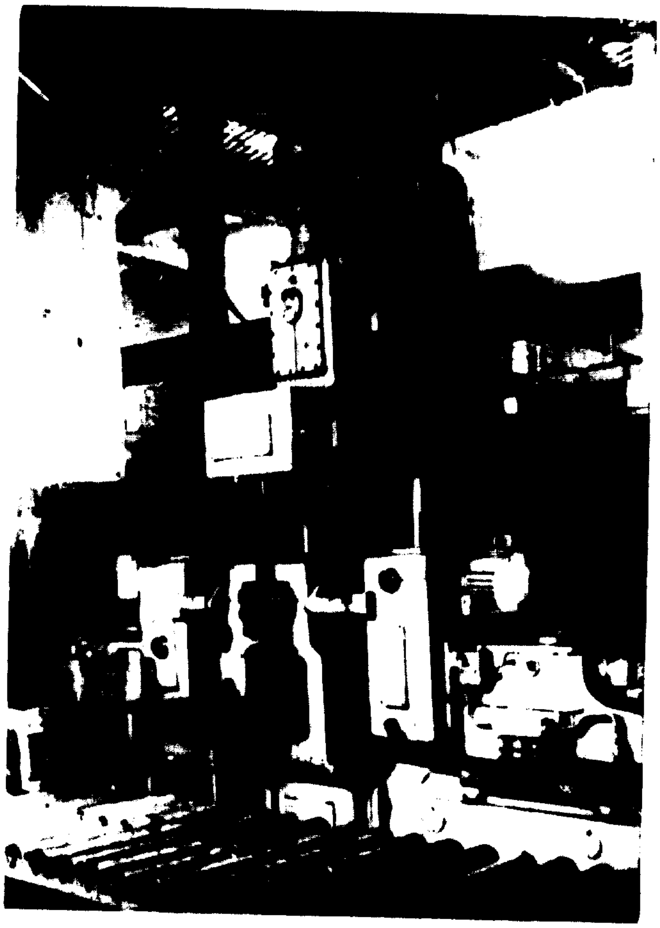


Figure 9

PLANT UNIT MACHINE FOR DRILLING AND CUTTING SMALL-DIAMETER HOLES IN AN APRON SHEET OF TYPE 1K62 THREAD-CUTTING LATHE

when the panels were manufactured at the Krasny Proletary works, a good set of fixtures for introducing mechanization into a number of manual operations in electric wiring, such as wire cutting and dressing, ring and connectors bending, were produced.

Mechanization is especially difficult in such painting operations as the filling and grinding of filled surfaces. Pulverization is applied as a filling method for small components having no large painted surfaces, e.g., hand wheels etc.

In the painting department, fibrous abrasive wheels, which are fitted to compressed-air grinding machines manufactured at the works in several versions, successfully cope with the grinding of filled-up component surfaces. Set-ups for airless painting have now been introduced at the Krasny Proletary plant to deal with the painting of machine components and entire machine tools. The new technique reduces the consumption of paint and simplifies the exhaust-ventilation systems.

It is clear, therefore, that the works' production engineers and technicians have done much to introduce mechanization in manual operations. Nevertheless, the fitting and assembly operations on the 1K62 machine tool are 40 per cent manual, and painting operations are 65 per cent manual, so the production engineers and designers still have quite a lot to do in this field.

B. *Group production line: group machining*

Because the Krasny Proletary works is engaged in large-batch production, the new form of production flow, viz., the group production line, has come to the forefront since the introduction of production line methods in the various plant departments.

The machining of frame components and those involving much labour, such as machine beds, unit bodies, spindles etc., is handled by fifteen individual production lines equipped with delivery arrangements, i.e., rolling tables for components to be transported from machine tool to machine tool, and individual hoists for loading and unloading the machine tools.

Components involving finishing operations of short duration (1.5–12 minutes), such as bushings, flanges, gears, shafts, covers, racks etc., which are most numerous in the 1K62 machine tool, are handled by thirty-three group production lines set up in mechanical departments.

The peculiarity of these production lines lies in the direct flow of components with respect to technological equipment and in the alternate finishing of the components assigned to the production line equipment according to design and technological similarity. The universal and special-purpose equipment installed on the group production lines permits readjustment, in the case of a standardized production process, to be effected within a comparatively short period.

As a result, the engineering facilities have been turned to better account and labour efficiency has considerably increased.

As an appropriate example, the group production lines installed at the gear section to finish as many as eighty-eight varieties of components are discussed below.

According to the design and technological features, the gears are classified into five categories, for which group production lines have been set up. The first handles as many as 14 varieties of components, the second, 25; the third, 22; the fourth, 21; and the fifth, an automated one, 6 types of gears.

As may be seen, the world's first automatic production line for gear manufacture (see figure 15), which was developed by ENIMS and which has been in operation at the works since 1958, is a group line. It comprises nine machine tools with two men in attendance and has brought about a three- to fourfold increase in labour productivity. Readjustment from one component to another takes 4–5 hours. The short readjustment time is accounted for by the specially designed setting fixtures which permit, for instance, cutter set-ups etc., to be replaced as a whole.

Another automated group production line for the manufacture of thirteen varieties of shafts and consisting of eight machine tools is in operation in the same department, it also was developed by ENIMS.

It can be stated for sure that the group production method alone has made it possible, under conditions of large-batch manufacture, to secure a profitable

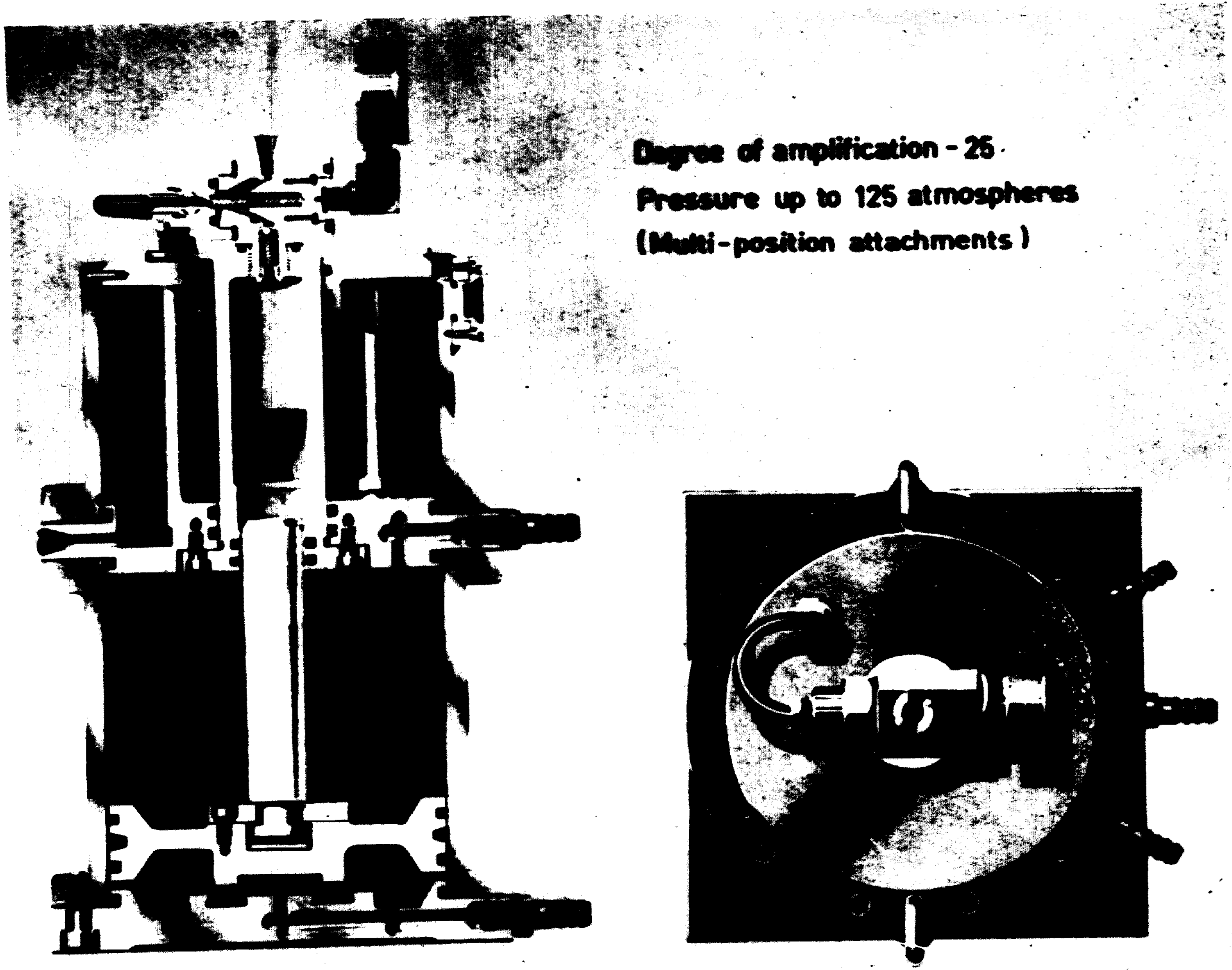


Figure 10

PNEUMO-HYDRAULIC AMPLIFIER

Figure 11

MULTIPLE-POSITION DEVICE WITH AUTOMATIC CLAMPS FOR MILLING A REAR MANDREL SHELL OF TYPE 1K62 THREAD-CUTTING LATHE

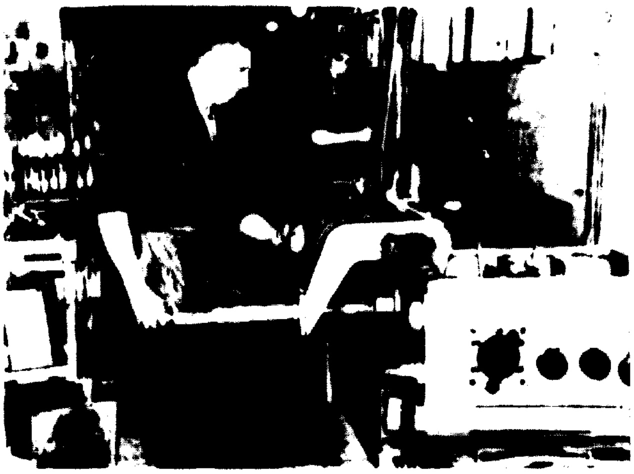


Figure 14

OVERHEAD HYDRAULIC CLAMP FOR PRESSING BOTH FLANGE AND SHAFT INTO A GEAR-BOX FOR TYPE 1K62 THREAD-CUTTING LATHE

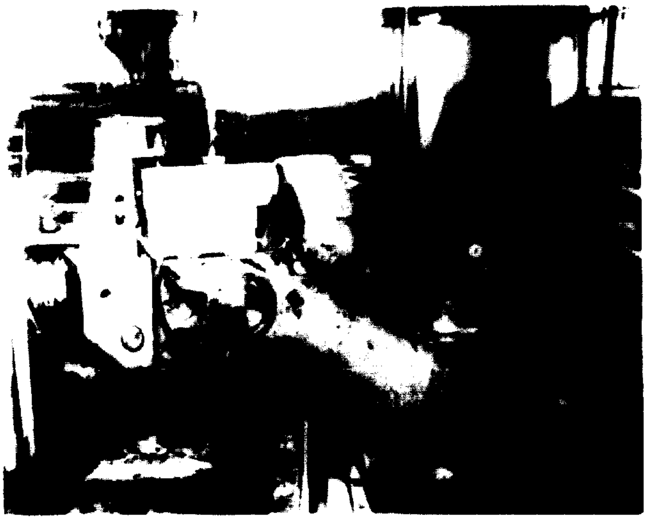


Figure 12

REVERSIBLE DEVICE WITH PNEUMATIC-HYDRAULIC CLAMP FOR DRILLING A REAR MANDREL SHELL

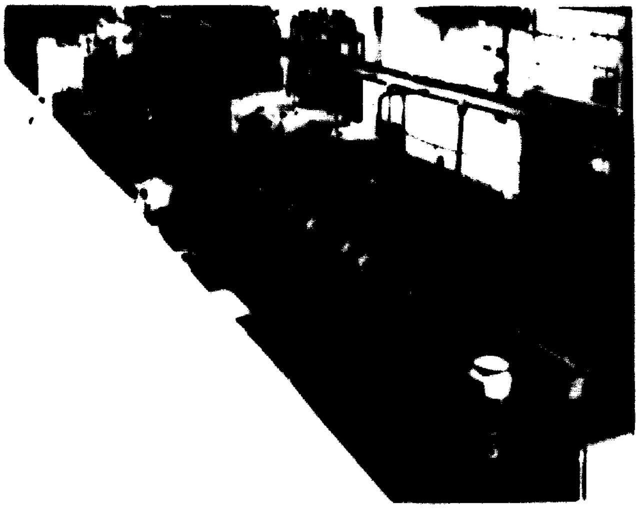


Figure 15

TRANSFER LINE FOR GROUP MACHINING OF GEARS FOR TYPE 1K62 THREAD-CUTTING LATHE

Figure 13

STATIONARY DEVICE, MOUNTED IN A ROLLING-TABLE LINE AND DESIGNED FOR HYDRAULICALLY PRESSING A BUSH INTO A GEAR-BOX SHELL FOR TYPE 1K62 THREAD-CUTTING LATHE operation of automated production lines. Although the first production lines built at the experimental Stankokonstruktsia works were equipped, as a rule, with individual machine tools, the lines were found to pay off in somewhat over five years.

Speaking of automation at the Krasny Proletary works, one cannot help mentioning certain failures encountered in equipment modernization. It was assumed that the automation of operating equipment was an important factor in raising labour productivity. At first, therefore, it was planned to introduce automation into entire individual production lines set up on the basis of operating equipment, for instance, in finishing spindles, flanges, chucks etc.

However, further work on the technical project for introducing automation into such lines revealed this solution to be absolutely unsatisfactory with regard to economic considerations for the works' scope of production. Computations showed that the costs would not pay off in less than fifteen to twenty, or even sixty years. The works, therefore, rejected such a broad automation of production lines and proceeded to introduce automation into separate operating machine tools.

In this respect also, a conclusion has been reached that, along with developing a reliable design for equipment automation, taking into account the large production series, a rational solution is obtainable solely with group-machining methods, which are being applied in different modifications to the operation of separate production lines, equipment and fixtures.

Group set-ups are widely used at the works in connexion with bar and chuck single-spindle and multiple-spindle automatic lathes and, partly, turret lathes. Such set-ups contribute to the manufacture of over 200 types of minor components and standardized pieces.

The application of standardized set-ups at multiple-cutter lathes has permitted the time involved in readjustment from one to another component to be reduced to within 20–30 minutes in the case of over 100 items.

The introduction of group-processing methods was found to be most difficult in connexion with special-purpose and unit machine tools. Nevertheless, the plant has succeeded in developing a range of new solutions. Given below are some instances of components, similar in design, dimensions, material and technology, being finished by group processing.

Eight-spindle semi-automatic lathes (models 1282 and 1284B) are used in conjunction with rapidly resetting gang-fixtures (turret-type cutter-holders, as shown in figure 16, chuck jaws etc.) to finish such components as flanges, gears and chucks. Resetting from one to another component has been reduced to three or four hours, compared with three or four shifts in the case of specialized fixtures.

The unit type of machine tools (models 2A921, 2A925, 2A927 etc.) handling such operations as drilling, countersinking and reaming, which are specially designed to cope with group processing, are used to finish from two to seven different components, e.g., forks, levers, brackets, covers and legs. Some of the machines are adapted to deal with a number of components without resetting (see figure 17). Some machine tools are changed over to other components within 20–40 minutes (resetting of cutting tools, guide prism, clamps etc.).

A special-purpose ten-spindle milling machine (model 2F367) is used to finish three dovetailed components, the

Figure 16

Turret type of tool-carrier mounted on a vertical eight-spindle semi-automatic lathe for group machining

Figure 17

Plant unit machine for group machining batches of seven items milling process extending to every surface of the components. The components are set up in a multiple-seat hydraulic fixture.

Owing to reduced time spent on resetting and the reduction by 2.5–3.5 times in total labour consumption, this equipment was found to be profitable for group processing in serial manufacture, with the pay-off period amounting to 2.5–3 years.

An important place also belongs to the gang type of technological fixtures, which take account of the peculiarity of large-batch production. The peculiarity lies in the fact that the works has developed highly efficient fixtures to secure, as mentioned above, both the required accuracy and the high operating speeds and feeds with the workpieces speedily and reliably clamped. Accordingly, the technological fixtures are largely individual. With large-batch production, it is quite justifiable because the fixures pay off within a short time.

In designing fixtures of this type, a very important aspect is the maximum reduction of the resetting time in a change-over from one to another component and from one to another fixture. In this respect, some interesting solutions have been found by the works' production engineers and designers.

Radial drilling machines have been equipped with rotary-tables for several jigs to be set up permanently to hold various components assigned to the machines, while they are being drilled. Such tables, which are circular or square, are provided with a centralized oil-supply to the hydraulic clamps. The resetting of the machine tool is reduced to turning the table with the required jig into a working position and switching on the hydraulic clamp, all of which takes 5–10 minutes, compared with the former time of 30–60 minutes (see figure 18).

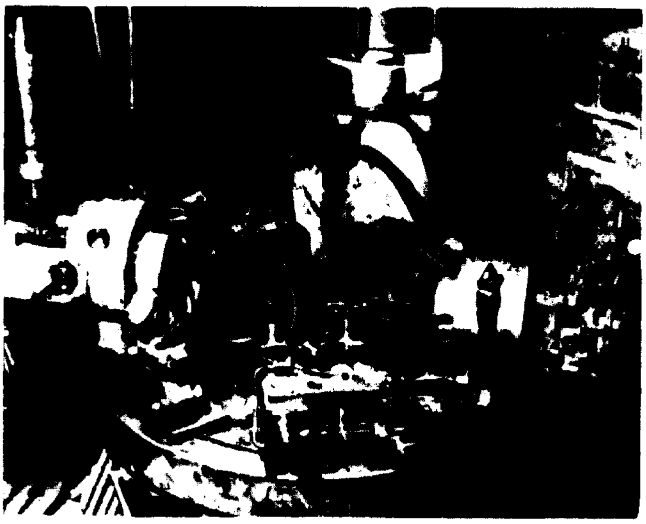


Figure 18

REVERSIBLE TABLE FOR GROUP MACHINING OF PIECES ON A RADIAL DRILLING MACHINE

Circular rotary-tables installed on vertical drilling machines, models 2125 and 2135, and using a number of multiple-spindle heads for different components to be drilled, have brought down the resetting time to 5 minutes, compared with the former time of 30–40 minutes. In this case, the resetting consists of several simple operations: releasing the table to permit its being turned into the working position; and retightening it (see figure 19).

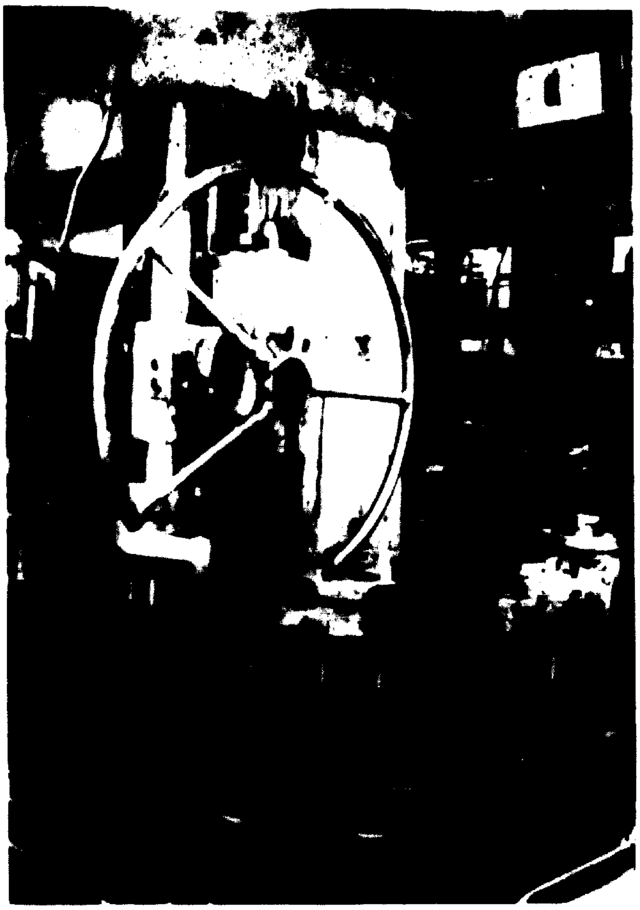


Figure 19

REVERSIBLE TABLE MOUNTED ON A VERTICAL DRILLING MACHINE WHEN A SET OF MULTIPLE-SPINDLE DRILLING HEADS IS USED

The use of readjustable tables for continuous milling with the aid of hydraulic clamps has considerably reduced labour consumption and has made it possible for several machine tools to be attended by a single workman (see figure 20).

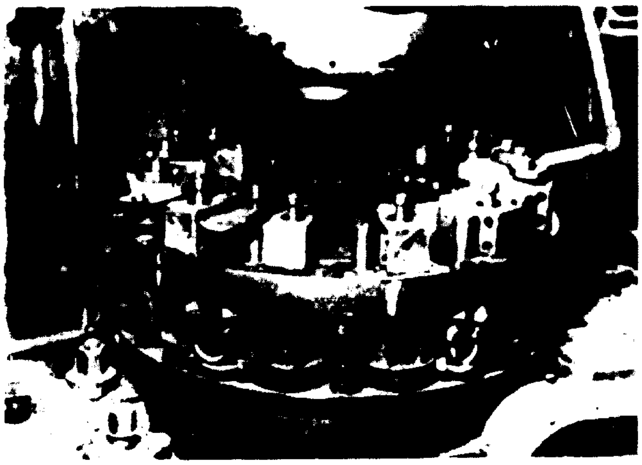


Figure 20

TABLE DESIGNED FOR CONTINUOUSLY MILLING PIECES

Good performance in drilling is shown by the quick-setting chucks with curved jaws used for clamping such components as flanges, gears and sleeves; clamping time is 8 seconds less, as compared with clamping in conventional three-jaw chucks; reduced manual effort is another result.

The group production methods have not been applied in mechanical processing alone. They have proved their worth also in the preliminary painting of components. Here, group conveyor lines have been set up to handle groups of machine components which are similar with regard to the technological process involved (see figure 21).

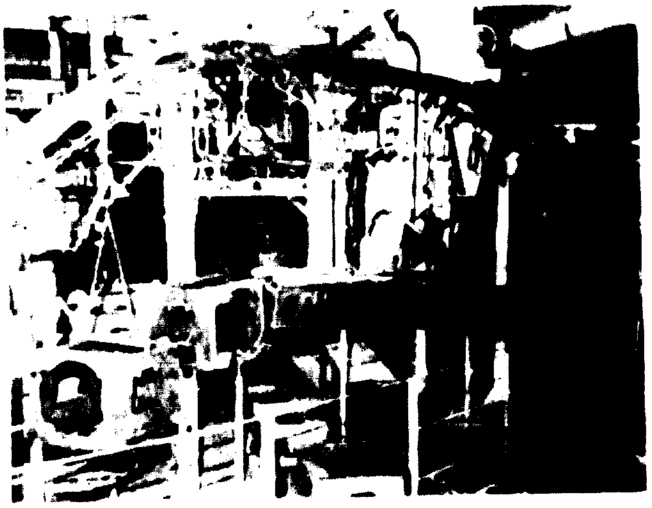


Figure 21

GROUP MECHANIZED TRANSFER LINE FOR PREPARATORY PAINTING OF MEMBERS OF TYPE 1K62 THREAD-CUTTING LATHE

In summing up, it should be mentioned that group production lines account for 90 per cent of all the components for the 1K62 machine tool and comprise 80 per cent of all the production equipment in operation. The rest of the equipment is installed in individual production lines.

C. *Complex flow, complex technology and mechanization*

The production line methods at the works embrace in a complex way all the stages of production technology in the manufacture of the 1K62 type of lathes: forging and preliminary operations; processing machine tool assembly; painting; and packing. Only with this complex coverage with production line methods is the efficient operation and regular manufacture of machine tools possible.

The group production lines in the forging preparation department are set up to deal with the hot punching of components on hammers and power presses. The heating furnaces, punching set-ups and cutting presses are interconnected with mechanical delivery facilities, e.g., track conveyors.

Production lines in mechanical processing have already been discussed.

The individual production lines in the assembling department are in the form of continuous-chain conveyors dealing with the assembling of speed-boxes, aprons and feed-boxes, as well as in the form of a drag-line conveyor for an over-all assembly of the machine tool (see figure 22). Production lines of the rolling-table type cope with the assembling of slide, carriage and tailstock.

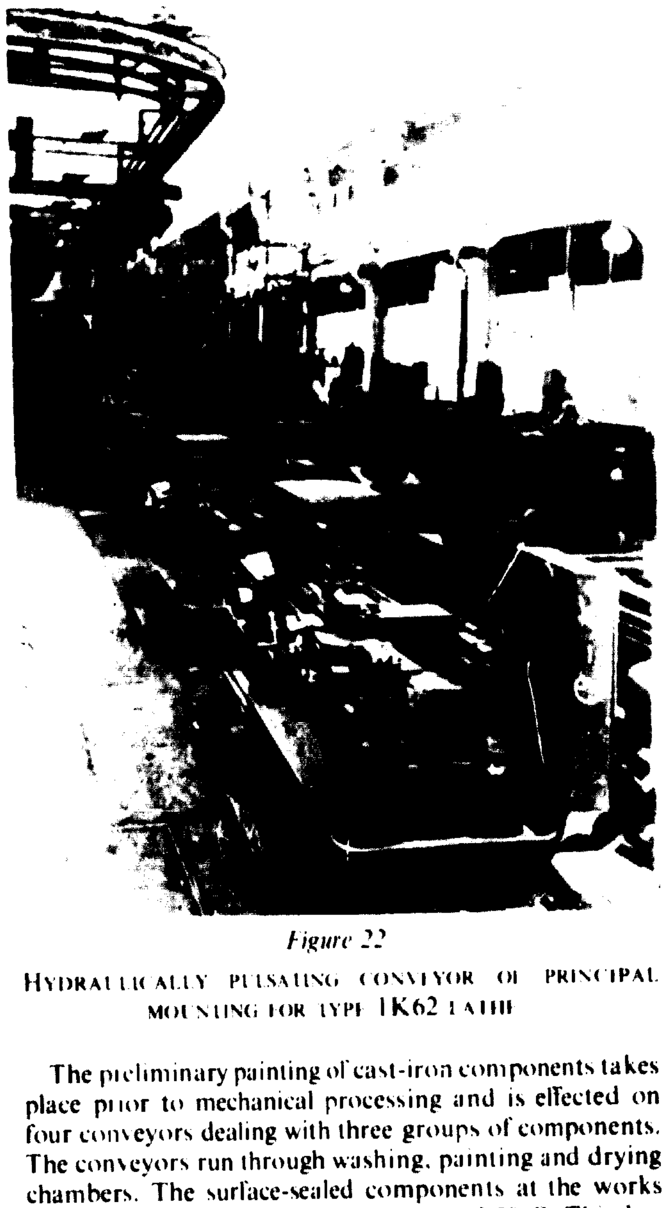


Figure 22

HYDRAULICALLY PULSATING CONVEYOR OF PRINCIPAL MOUNTING FOR TYPE 1K62 LATHE

The preliminary painting of cast-iron components takes place prior to mechanical processing and is effected on four conveyors dealing with three groups of components. The conveyors run through washing, painting and drying chambers. The surface-sealed components at the works are artificially dried at a temperature of 50 C. This has contributed to high surface quality and has reduced the cycle of component processing by more than ten times. The painting of sheet components is also handled by a suspension conveyor comprising a washing unit, thermo-radiation drying and painting chambers.

The ultimate painting of assembled machine tools is carried out on two conveyors. The pallet conveyor is the place where first dressing and sealing work is done, while a circular conveyor running through three nitro-chambers handles the machine tool for triple painting with the use of spray-guns and airless-painting sets (see figure 23).

The packing of machine tools in packing boards carried out on a manœuvrable bar type of roller conveyor.

Production line methods presuppose the large-scale mechanization of all production processes. Mechanization problems should be solved in a complex way, i.e., in relation to both main and auxiliary operations. At first, while introducing production line methods, the works' attention was focused primarily on bringing mechanization into the main operations. Later, mechanization was extended to a great many auxiliary jobs, and the results were quite satisfactory in a number of cases.

Figure 23

RING CONVEYOR FOR PAINTING TYPE 1K62 THREAD-CUTTING LATHE

The mechanization of auxiliary operations in the main departments proceeded along three lines: mechanization of chip removal; mechanization of handling; and mechanization of storage operations.

The system of chip removal consists of conveyors which are arranged between the rows of machine tools and are in metallic boxes sunk under the floor: a scraper-bar type of conveyor handles cast-iron swarf and a rag-bar type of conveyor deals with steel, usually spiral chip.

The chip from the machine tools is dumped onto these conveyors either with the aid of special worm-screw conveyors or directly by the workmen. The conveyors deliver the chip for dumping onto the central conveyors, which take the chip to the place where it is compressed into briquettes.

Prior to briquetting, however, the steel chip is crushed in hammer crushers. The combination of chip removal and chip briquetting permits the works to save as much as 100,000 roubles per annum, the pay-off period being 1.5 years.

Under conditions of serial production, the organization of indoor interoperational handling poses some serious problems.

For trouble-free work in all operations, it is necessary, along with delivering the components from operation to operation, to make arrangements for storing up reserve pieces at the work-station and, what is more, not in one but in several varieties of components.

Rolling-tables are used as transportation facilities for the majority of production lines in the mechanical departments. These tables deliver from machine tool to machine tool or from the department to the storage area either separate machine-body components or small-size pieces in standardized tray or pin packages.

Under the conditions prevailing at the Krasny Proletary works, this type of transportation, in the case of machine-body components in combination with rolling tables, is quite justified in some cases. On the lines of small-size components, however, the rolling tables have lost manœuvrability and, as the component batches grow in scope, are being increasingly converted to a kind of storage place. For several years, the plant has been in search of an adequate indoor transportation solution, but it has not yet discovered a system that would fully meet its requirements; therefore, the work on the problem is continuing.

The address type of conveyance system was rejected because of the great complexity and high cost of the equipment involved.

A simplified system of monorail transport is currently being used at a number of production areas. To this end, the storage of machine components is achieved in iron containers which can be stored in several tiers, or the components are kept in special containers and moved along the rolling tables.

The large-capacity containers in use at several production sections permit the storage of components in several tiers.

Highly interesting mechanizational facilities are used at the works for intermediate component storage and for delivering components from the mechanical department or from the storage area to the assembly department.

Transportation of components without replacement is handled by standardized containers in the form of hollow punched trays or trays with pins. The trays with components delivered for storage via rolling tables from the mechanical department are stacked by special stackers. One stacker takes care of two rows of stacks. For the trays with components to be delivered from the storage room assembly places, a suspension conveyor is put into operation. The conveyor is loaded with the aid of the stacker and special elevation tables installed at the storage loading-station. Along the conveyor route, there are unloading stations at three assembly places.

The component-filled containers are addressed from storage to any one of the three unit assembly places and are unloaded there automatically. Having been brought to an assembly section, the trays with components are deposited on roller-mounted stacks in direct proximity to the assemblers' work-stations. The emptied containers are hung on the conveyor's idle grips to be brought back to the storage section and further to the mechanical department.

Highly effective mechanization has been introduced into storage operations and into the delivery of components from the storage to assembly via a suspension conveyor, in combination with standardized containers. The multiple reloading of the components has been eliminated thereby reducing damage (dents) caused to components, and the storeman's labour has become far more effective and easier. The storage capacity, as well as the capacity of the magazines, of the work-station storage receptacles, have been raised also. The check of component movement has been facilitated.

Transportation of machine-body components from the mechanical to the storage departments is handled by a special underground conveyor which, bypassing the storage area, delivers components directly to the three sections on the first and second floors of the assembly department. At the section areas, step conveyors are used to deliver components to the work-stations.

In the assembly department, the assembled units (headstocks, saddles, aprons and feed-boxes) are handed over for mounting and tested machine tools are turned in for trimming via special conveyor.

These mechanization facilities have reduced by half the number of workmen employed on the delivery of components and units, and on storage attendance, the pay-off period somewhat exceeding a year.

However, not all of the auxiliary jobs at the works, especially those relating to the all-works handling storage facilities, have yet been adequately mechanized. Auxiliary jobs have been mechanized 46 per cent, whereas in the main production operations, the share of mechanized labour is as high as 70 per cent. New efforts are currently being made to introduce mechanization into auxiliary jobs.

It should be noted that the works has developed detailed technological procedures in basic production operations, and time rating is maintained. The auxiliary jobs, on the other hand, have not yet been subject to technological regulations and are, consequently, rated but insignificantly. For this reason, a technological bureau has been set up at the chief production engineer's department to deal with auxiliary jobs. The function of the bureau is to draw up production procedures for handling, storage and auxiliary jobs. Such procedures will furnish a basis for rating to be introduced into auxiliary jobs and for more rational solutions to be evolved for various mechanization problems. Thus, a complex production technology is being devised for the entire production cycle at the works, beginning with the reception of materials and ending with the delivery of finished products.

II. Prospects at the works

Large-scale reconstruction is under way at the Krasny Proletary plant, which will serve as a model works as regards the level of mechanization, organization of production and working conditions.

A new building for the manufacture of vertical multiple-spindle semi-automatic lathes was built and has been in service for over a year. These machine tools are also being manufactured on a production line with the use of group production methods. Efforts are being made to introduce special-purpose equipment, gang fixtures and complex production methods, i.e., along with basic operations, mechanization is being extended to such auxiliary jobs as chip removal and component handling.

Preliminary computations show that labour consumption on the machine tools manufactured in the new building will be reduced by nearly two times.

Much work is to be done in connexion with further perfecting the production line methods in the manufacture of lathes in departments now in operation.

Additional quality improvements on the machine tools now being turned out will receive a great deal of attention. The problems of quality are being approached, first of all, from the standpoint of improved accuracy, reliability and long life of both the separate components and the machine tools as a whole.

To solve properly the problems of quality under the conditions of production line manufacture, it is necessary to undertake extensive and serious preparations for putting into effect whatever measures have been conceived.

The works' designers and production engineers face the prospect of great creative work on these lines. This work is organized in collaboration with a number of research and design institutions ENIMS, the Central Production Research Engineering Institute (ZNIITMASH) etc.

The new model of a universal screw-cutting lathe (16B2OP), which was designed in the works' design department, will be superior to the current 1K62 model in accuracy and service life. The first experimental specimen was manufactured at the end of last year. The designers and production engineers are taking steps to put this new model into serial production. This will be preceded by thorough work on the technological aspects of the new model's design and by the manufacture of experimental batches of machine tools.

In addition, work is in progress to introduce some modifications into the 1K62 machine tools now being manufactured by production line methods. For their accuracy to be improved, the finishing and trimming operations must be more numerous, the composition of the production lines revised, the production equipment layout altered and new supplementary fixtures developed. All this must be realized without stopping the production of machine tools; therefore, each measure is subjected to a carefully compiled schedule which envisages the entire volume of design and technological preparations, and laboratory and production tests before the measure can be finally incorporated into serial production.

Special attention is currently being paid to quality improvements in such important parts as the machine beds and gears, by resorting to various technological measures. For many years, the machine beds have bee manufactured with the aid of high-frequency currents, with their ways hardened, which makes them highly wear-resistant. This operation is handled by a high-frequency current set-up installed in the production line and comprising a special mobile table for the machine bed to be put on (see figure 24).

Figure 24

TYPE TB INSTALLATION FOR TEMPERING SLIDE BARS OF TYPE 1K62 LATHE BED

In the past year, the works has introduced a new advanced method for grinding the hardened machine-bed ways with the grinding-wheel's periphery. Apart from raising labour efficiency by 30–40 per cent, this method also improves the quality of machine beds in the geometry of their ways.

Modernization of the high-frequency current set-up for the hardening of machine-bed ways has reduced deformations and improved hardness stability.

The foregoing examples of efforts aimed at quality improvement reveal that the current work in raising labour productivity must be coupled with measures calling for the larger labour consumption required by extra finishing and other operations. These problems directly affect the works' economy. For instance, the flanged spindle, which was introduced on the 1K62 type of machine tool and which has substantial advantages over the former spindle (with a threaded end), has accounted for an increase of 16 kg in metal consumption and an increase of over three hours in finishing time. Therefore, every measure aimed at quality improvement, under the conditions of mass production, must be taken in consultation with all of the works' services, including economic services.

In the light of the problems currently facing the works, the creative activities of production technology personnel, production engineers among them, become highly important. Production engineers are, in fact, the creators of new technological processes, the organizers of production lines and the sponsors of ideas relating to the mechanization of production processes.

At the current time, the growth of the technological cadre and the improvement of their skill and "know-how" is no less important than the growth of the staff of designers.

The experience accumulated by the Krasny Proletary works is large enough for the problems facing it to be solved. The works is well known throughout the world, it has extensive economic contacts with other countries and delivers machine tools to nearly sixty of them.

During the period 1930–1932, the works' personnel were engaged in preparations for the manufacture of a new lathe model called "DIP", which stood for the words "overtake and leave behind", to signify that the Soviet Union would become the leader in the world machine-tool industry. The men at Krasny Proletary were very enthusiastic about beginning the new production programme and introducing the novel production procedures. The target, "to overtake and leave behind", was achieved within a short time by the works' personnel.

The path covered by the works since that time has been marked by persistent efforts for technological and organizational improvements. Many highly skilled specialists in machine-tool building have been educated at the works, among them production men and designers who are now working there, as well as at numerous establishments elsewhere, in both the machine-tool industry and other fields.

Many of those who made parts for the first machine tools and assembled them now hold top-level posts at industrial establishments or are engaged in important engineering work, either at Krasny Proletary or elsewhere.

All these facts emphasize the correctness of the path taken by the works in setting up production line systems in machine-tool building and in making use of mass production technology and manufacturing methods

5. 4. 74