In recent years particular attention has been paid at the enterprises of the Ministry of the Machine-Tool Industry (Minstankoprom) to adopting process control systems, which measure products in the course of their machining and control the technological process according to the allowance and the current size. The application of highly productive machining methods (high-speed and power grinding) has brought to life a basically new variety of process control, namely, the adapted systems, which control the process according to such parameters as the allowance removal rate, variations of the component's temperature, etc.

The machine cycle on modern machines lasts 6-9 sec and the dispersion in the rate of feeding during one shift attains 50% or more of the nominal value. Therefore, in the case of ordinary process-control systems, at the instant when the instruction which carries information on a given setting and stops the feed is received, the machine deformations can have diverse values, thus producing considerable errors. Under such conditions it is necessary to bear in mind the above factors and correct correspondingly the technological process for each component's machining. Such systems should be equipped with electronic calculators or parts thereof. The application of process-control systems serves to raise the machine operators' labor productivity, improve the quality of products, automatize the machining process, reduce the volume of subsequent testing operations, and employ less skilled operators. Thus, the process-control measuring systems are suitable for solving a series of important technological, metrological, and economic problems.

Testing and sorting automatic machines substantially raise labor productivity in testing operations. It should be noted that the former machines only indicate rejects, and their application shows that the technological process is either insufficiently precise or stable. Their utilization will be reduced and limited to acceptance testing of products which consists of several components or a single one with a complicated configuration whose elements have a combined effect on the quality index. They will also be used in the manufacture of special products.

The application of testing and sorting automatic machines which separate products into size groups for their subsequent selective assembly is economically expedient and sometimes the only possible technological method for obtaining precise matching. These machines are used increasingly, especially in the production of bearings and fuel-feeding equipment, and this does not exclude, but on the contrary presupposes the application of process control systems as well.

One of the basic tendencies in the development of measuring equipment intended for operational control at work benches consists of a wide application of dial instruments instead of gauges. These instruments serve to determine the actual value of the machined component's dimension, to evaluate the deviation from the given geometrical form, and to correct accordingly the machining process. This circumstance made it necessary to increase sharply the production of work-bench instruments, including those with a high precision.

The characteristic and very promising feature in the development of the linear and angular measuring equipment consists of a wide application of new measuring principles, and above all those entailing electronic, luminous-pulse, laser, and other devices. The inductive, capacitive, and photoelectric principles of operation are used in producing measuring equipment which is considerably superior in its metrological characteristics to that based on other principles of operation.
The luminous-pulse linear and angular measuring transducers are used for producing flexible high-precision measuring systems for testing products of a complicated shape (gears and transmissions, turbine blades, etc.).

The next five years will be distinguished by a wide application of computers in measuring equipment for the purpose of processing and analyzing measurement results, testing components with a complicated shape according to a given program, and controlling technological processes on the basis of the measurement results obtained by means of process control equipment. The so-called minicomputers will be mostly used. In certain cases computer elements will be incorporated directly in the instruments. The utilization of computers in the linear and angular measuring equipment will sharply raise its efficiency, especially in the case of processing and analysis, including harmonic analysis of the results obtained in measuring products with a complicated shape, when a large number of intricate calculations is required.

Computers can also be used effectively in instruments for testing shapes, for instance, circularity, or especially cylindricity. In the latter case we use at present highly inefficient and subjective evaluation methods. The jig-boring and measuring machines, which are being increasingly used, provide 90% of their measurements with an error of the order of 0.01 mm and are suitable for testing products with a complicated shape. These machines combined with computers are suitable for obtaining by means of sequential measurements an object's actual dimensions and relative position of its surfaces, and comparing them with the specified ones. The information on the respective deviations thus obtained can then be used by the machine for correcting the technological process. These computerized machines can also be used for producing machining programs from the results obtained in measuring a reference component or model, and for marking off complicated components.

The requirements of industry in a wide range of measuring instruments can be met and their rational servicing and repairs obtained by establishing a uniformized system of instruments and their functional units. Such an approach is also necessary because various types of elements, especially electronic ones, obtained from other systems are often used in the measuring equipment. This predetermines the uniformity of input and output signals, as well as the connectors and overall dimensions.

How are these tendencies in the development of measuring equipment implemented?

Process control systems based on pneumatic measurements are the most widely used. The Interchangeability Bureau (BV) developed a uniformized process control system which incorporates a controlling calculator BV-6060 and diverse measuring instruments in general-purpose machines. This combination is suitable for controlling components with smooth and discontinuous surfaces, carry out combined grinding, etc. The aggregate is produced by the Chelyabinsk measuring instruments plant in various versions with scale factors of 0.2, 0.5, and 1 μ, and with two or four instructions for controlling the machining process. The basic aggregate is used as a foundation for developing measuring equipment and systems as well as machine tools of a special type.

Further development of the process control systems is characterized by a wide application of electronic principles of operation with the inductive method being preferred.

At present the Interchangeability Bureau is developing and the Chelyabinsk measuring instrument plant (ChZMI) is simultaneously mastering the production of a wide range of process control and measuring systems which are based on the inductive principle of operation and are suitable for testing smooth and discontinuous surfaces with storage of the controlled dimension's extremal values and for testing stepped shafts and axle orientation equipment. These systems can also be used with suitable adapting devices for controlling machining processes by measuring the rate of the allowance removal, above all in the case of high-speed power grinders. The systems thus produced are intended both for the existing stock of machine tools and for the newly-developed ones, including circular, internal, and face grinders, and special machines.

The system's basic unit consists of a controlling calculator BV-6119, which has two scales with factors of 5 and 1 μ and delivers two or four instructions to the machine-tool control circuit.

The process-control measuring systems based on the inductive and pneumatic principles will coexist. The reason for this parallelism is due to the fact that the pneumatic principle is at present suitable for producing systems which are simpler, less expensive, and more stable in operation. These considerations in many instances are decisive for selecting process control systems. Pneumatic process-control systems are beyond compare when it is necessary to use contactless measurements. This is why the inductive process-control systems include pneumoinductive transducers, which combine the advantages of both principles of operations.

A range of inductive measuring systems was developed for operational control and their mass production has been on the whole mastered by the "Kalibr" plant. They have uniformized output signals suitable for operating