The constantly increasing production of gears and their rising precision requirements have set for the instrument-making plants the task of producing a great variety of gear testing instruments and of extending their production.

The instrument plants of the USSR now produce over 50 standard sizes of instruments for testing gears [1], whereas 25 years ago only four types were produced. Moreover, only one of them was of the machine type, the remaining being superposable. Soviet instrument making has certain specific features in the sphere of gear testing techniques. They are concerned with a combined examination of three aspects of gear irregularities consisting of the errors arising in manufacture, their detection in testing, and their effect in use; specification of requirements for the gear testing equipment according to its application at different stages of the technological process; establishment of certain uniform design principles for all the gear testing instruments produced in the USSR.

Gear Irregularities. Normally, in examining the irregularities of gears, such of their component errors are taken into consideration as those of their base and circular pitches, radial wobble of toothing, etc. This in many instances makes it difficult to establish the relationship between the gear errors and the infringements of the manufacturing technological process, to find the pattern of their variations, and it leads to difficulties in dealing correctly with the errors appearing in the application of gears (affecting noise in their operation, their dynamics, etc.).

It was found that the most effective method is the one developed in the USSR [2] of considering all the problems entailing the appearance, measurement, and effect of errors in their mutual relationship, thus taking into consideration the functional nature of measuring an effective error of a gear and referring all the errors to a single registering system [3].

The functional errors of a gear become apparent from studying the errors of the tooth-cutting kinematic process which are combined with the errors of the tool and its setting, the geometrical errors of the machine and of setting the blank. The majority of these errors vary periodically.

The system of registering errors consists of superposing on the tested gear a rack profile and the two potential lines of action associated with it (Fig.1). The errors which change with the gear's angle of rotation are considered as excess increments \( \Delta F \) along the line of action over which the movement is transmitted from the actual gear to the rack profiles. The rack profiles and their displacement to the left- or right-hand sides are considered independently.

The application of these considerations has determined the development of work for normalizing the precision and the testing of gears in the USSR.

Types of Gear Testing. The gears are tested at various stages of their manufacture. The aims pursued in testing and the requirements specified for the gear-testing instruments differ at each stage.

In the USSR it is customary to distinguish three types of gear testing, consisting of final, technological, and preventive testing.

Final testing aims at finding whether the precision of manufacture corresponds to the requirements which depend on the intended application of the gear transmission. Final testing is made by means of direct checking of gears. This type of testing is combined and is made by aligning the measuring base with the mounting base of the product. Thus, final testing should provide a continuous characteristic of the kinematic precision and the smooth operation of a gear in its transmission, of the teeth working surfaces' contact areas, and of the value of lateral clearances over a complete turn of a gear (Fig. 2). The instruments in final testing should be highly efficient, and it is desirable in their case to apply mechanization and automation.
Technological testing serves to detect errors in the technological process by testing the gears, and it is made with the aim of adjusting and trimming the technological equipment, such as machines, tools, and accessories.

In order to find by means of technological testing the effect of each specific technological factor, it is necessary to align the measuring base with the technological base, and not the mounting base as it is required in final testing. Therefore, in this case separate elements of gears are tested, such as the deviations of the profile of the base pitch, beating in the course of gear grinding, etc. Instruments for technological testing must have a higher precision. Normally they are not mechanized and their testing process is considerably more labor consuming and less efficient than the final testing process.

Preventive gear-production testing includes checking the geometrical and kinematic precision of the gear cutting machines, testing gear cutting tools when they are new and after sharpening, checking accessories used in machining gears, and testing blanks. Preventive testing becomes particularly important in manufacturing precision gears and in mass production.

The difference in the objectives of final and technological testing leads to different specified requirements for the measuring instruments in question and, in particular, for their endpieces. Thus, in final testing the instrument’s measuring member (endpiece, measuring gear, rack, or worm gear) must engage with the tested gear under conditions approximating most closely the operating conditions. For instance, the measuring gear should engage along the entire height and length of the tested tooth at an angle of pressure approaching the one existing in the actual transmission.

In technological testing the instrument’s endpiece should reproduce the engagement conditions existing in the machining of gear profiles, i.e. it should contact the teeth at the same points as the machining tool did in the course of gear cutting.

Basic Specific Features in the Design of Soviet Gear-Testing Instruments. The above-mentioned principles of considering the continuous functional error as increments along the two lines of action, together with the classification of tests and differentiation of their objectives, are materially reflected in the design of the gear-testing instruments.

The main specific features of the Soviet gear-testing instruments can be illustrated on the example of mass-produced instruments.

The instruments produced in the USSR for testing base pitches of gears with external meshing are provided with two tangential (flat and knifeshaped) endpieces. They represent the two adjacent profiles of the toothed rack and engage with the tested gear (Fig. 3). This serves to determine the distance between two parallel straight lines tangential to the two similar adjacent profiles instead of measuring the distance between two profiles along the normal to one of them. Measurements by means of two tangential endpieces makes it possible to detect the error which is effective in the operation of the wheel over the entire overlap angle between the adjacent profiles. This is important for gears which have a noticeable error in their profile.

The tangential knife-shaped endpiece is also used in the instrument for testing the direction and lead of the contact line of a helical gear UZP-400 and in a superposable instrument for testing the linearity of the contact