AN INSTRUMENT FOR CHECKING THE RECTILINEARITY AND AXIAL ALIGNMENT OF LARGE-SCALE PRODUCTS

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The DP-477 optical level, mass produced by the optomechanical industry [1], is intended primarily for checking the rectilinearity of large flat surfaces and is widely used in various branches of the machine-building industry providing, as a result of the absence of focusing, highly accurate and reliable measurements in checking such large-scale products as the beds of heavy lathes, foundation frames of high-power diesel engines, layout blocks, long leveling rules, etc.

For other types of inspection and installation works associated, for example, with checking the axial alignment of individual units of composite large-scale products, we have designed a new version of the optical level, the DP-725M instrument. The operating principle of this instrument is the same as of the DP-477. It is based on sighting a remote luminous mark by means of a telescope. The diameter of the sighting telescope objective has been reduced from 75 to 45 mm while preserving the basic relationships between the structural elements of the spherical axicone unchanged [2]. For measuring axial displacements we have preserved the compensator consisting of an inclined plane-parallel plate mounted in front of the telescope objective, with the axis of oscillation of the plate turned through 45° with respect to the XX and YY cross wires of the ocular grid (Fig. 1). The measurements are carried out by tilting the plane-parallel compensator plate so that the image of the luminous aperture coincides first with the YY and then with the XX cross wires. The image in the form of a round light spot A moves at an angle of 45° with respect to the cross wires. At the instant of coincidence of the light spot center with the cross wires (positions A1 and A2), the micrometer drum indicates the magnitude of displacement directly in linear units (in microns). The \( \sqrt{2} \) magnification due to the oblique motion of the light spot with respect to the cross wires is taken into account in calculating the thickness of the compensator plate. Such a construction of the sighting telescope [3] makes it possible at once to take readings in both coordinates using a single compensator plate and a single readout drum. This considerably increases the accuracy and efficiency of measurements.

The basic optical elements of the sighting telescope 1, 2, 7 (Fig. 2) are mounted inside a rigid cylindrical housing 9 with a mounting diameter of 64 mm finished to class 2 tolerances. The position of objective lenses 2 and...
8 and of the cross wire center of grid 6 are such that the optical axis of the system coincides with the geometric axis of the cylinder 9. The readout drum 4 of the compensator is located near the ocular 5 for the sake of convenience. Motion of the micrometer screw is transferred to the plane-parallel plate by means of the shaft 3.

For checking the rectilinearity of plane surfaces, the telescope can be mounted (Fig. 3) by means of a spherical bracket 4 on a carriage 3. The telescope is aimed on the marker by tilting it around the center of the bracket 4 by means of the control screws 5 of the carriage. A dismountable magnetic base can be used for reliable mounting of the telescope and carriage on steel or cast iron surfaces (materials most frequently used in heavy machines building). For checking the axial alignment of several holes, the outer surface of the tube together with the optical axis of the system serve as a base in relation to which the axial position of the holes being checked is determined. The telescope is mounted by means of a spherical clamp and a special bracket on the last hole and the sighting axis of the telescope is aligned with the hole axis. Then, marking the axes of next holes to be checked, their position is determined with respect to the sighting axis which serves as the base of reference. For convenient setting into holes in case of checking axial alignment the marker of the new instrument has a cylindrical mounting surface 50 mm in diameter finished to class 2 tolerances.

The illumination system and the exchangeable point diaphragm are on the same axis as the mounting surface; the illuminator diameter does not exceed 45 mm. Such a marker can be easily placed at center of any hole with the aid of various center finders and adapter plugs. Devices for mounting markers on the axis of a checked hole providing various readout accuracies are discussed in [4].

For checking the rectilinearity of plane surfaces, the cylindrical marker is placed in a stand with a plane bearing surface. The stand has two micrometric screws 1 which allow the marker to be moved in two mutually perpendicular directions within the range of ±5 mm. The micrometric screws simplify instrument alignment and facilitate measurements when the measured magnitude exceeds the limits of the optical compensator of the telescope. Since the brightness and the visible diameter of the marker image in the telescope field of view change with the operating distance, the marker is supplied with a set of interchangeable point diaphragms 2.

For measuring rectilinearity and axial alignment in two mutually perpendicular directions, the instrument is supplied with a telescope adapter 1 (Fig. 4) consisting of a pentaprism 2 and wedge 3. The pentaprism face in contact with the wedge has a semitransparent coating. The directions of the two beams are perpendicular to within ±2°. The operator observes markers placed along the sighting axis in the direction A1A2 and at the same time records the position of markers in the direction C1C2 normal to A1A2. The axial alignment of the outside telescope housing with the sighting line makes it possible to place it in a strictly horizontal position. The instrument is fitted for this purpose with a laid-on level whose bearing surface has the form of a prism. With the aid of this level it is possible to check the position of the checked surfaces in relation to the horizontal line. Magnetic adapters provide reliable fastening of the markers and telescope when checking inclined, vertical, or even "top" surfaces of various products. The new construction and accessory devices improve the versatility of the instrument.

The instrument has the following technical specifications: operating limits 0.2 to 50 m; sighting error ±(1 + 0.5L) μ, where L is the distance from the front of the telescope to the marker in meters; maximum deviations measured by the sighting telescope compensator and by the marker micrometers ±0.5 mm and ±5 mm respectively, scale value of the readout drum and of the marker micrometer 0.001 mm and 0.01 mm respectively, axial misalignment of the optical axis of the system with respect to the outside diameter of the sighting telescope and marker ±0.01 mm.

Experimental models of the instrument successfully passed all tests in industrial conditions. It can be noted in conclusion that the basic advantages of the new instrument: high measuring accuracy at large distances, versatility (the instrument is capable of checking rectilinearity, axial alignment, perpendicularity, and horizontality), the possibility of checking surfaces arbitrarily positioned in space, reliability and speed of measurements, convenient