

SOLUTIONS FOR THE INTERNAL KEYWAYS POSITION DEVIATION MEASUREMENT

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ABSTRACT: The measurement of symmetry and nominal position deviation from theoretical point of view is not a problem, the main issues appears when these theoretical aspects aren't applicable in industrial practice. The problem addressed in this paper is to identify the possibility to develop a method for the intermediary control like a necessity to industrial practice but for a small series production. A theoretical analysis was developed in order to identify the measuring possibility of symmetry and nominal position deviation for a specific keyway. Using chart ideas and making a case study, we thought to find a practical solution of the intermediary control for specific keyways gears, in small series production case. The research tries to highlight some common and distinct aspects specific for those measuring methods and to solve the issue of intermediary control for a small series production in case of gears internal keyways.

KEY WORDS: internal keyway, measurement, nominal position deviation, symmetry, control device.

1 INTRODUCTION

The importance of the keyway in mechanical engineering is related to the key role, that must prevent relative rotation between the two parts and enables torque transmission. Any geometrical or position deviation has a great impact on product performance, so that development of a proper measurement method it imposed (Vignat et al., 2013). The goal of position tolerance is to ensure assemblability of parts. It is important in any measurement system to reduce the errors to the minimum possible level. There are many factors and different sources that often arise and modify the measurement results. One can refer at the variable size of the workpiece, the material non-uniformity, the rigidity of working system, the cutting tool wear and especially the working method (Hinds & Ong, 2014). The scientific literature gives the broaching like the most accurate of all the processes for the internal keyway. Specific to this process is the fact that the bushing and the guide are used for each given keyway cross-section so that this process is more expensive than most of the alternatives. The other processes used for keyway are: milling, keyseating, unconventional technologies (wire electrical discharge machining). Now the development of the tool area allows today computer numerical control (CNC) lathes and CNC mills to broach internal keyways with special broach tools.

Depending on the tool and the machining process, the internal keyway can be done with success but different problems appear for the controlling methods of some parameters.

The measuring possibility of the deviation from symmetry or nominal position depends on the type of control and also on the selection criteria of the means and methods of measurement. These criteria take into account: the controlled parameter, the shape, the size and the mass of the part, the accuracy of measurement, the productivity, the possibility of execution or acquisition, safety in operation, the cost price, the requirements imposed to the operator, the flexibility of use, the maintenance and repair capabilities, the ergonomic and aesthetic features (Mircea, 2004). One of the major difficulties encountered in controlling position deviation (nominal position or symmetry) is to measure these deviations independently of dimensional accuracy and surface controlled micro and macro-geometry and those considered as reference base.

The ISO standard gives the characteristic for this kind of deviation, so that the median surface shall be contained between two parallel planes with certain values apart, which are symmetrically disposed about the theoretically exact position of the median plane, with respect to given axis A (JCGM 200:2008, 2008), (ISO 1101:2004, 2004). Start with this the literature offers several solutions for symmetry measuring deviations by using universal means and special measuring instruments. If the production is of large series, type gauges with special construction can be used. If the pieces are small size and thickness one can use large workshop

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microscopes or profile projectors. They also built and designed specifically callipers that measure the deviation from symmetry.

A synthetic view regarding the methods of measuring the position deviation can be observed in

Fig. 1. This paper have not taken into consideration all possible means of measuring, but only those related strictly to the surfaces position control, those that were relevant to the case study (Mircea, 2004), (Kosarevsky, 2012).

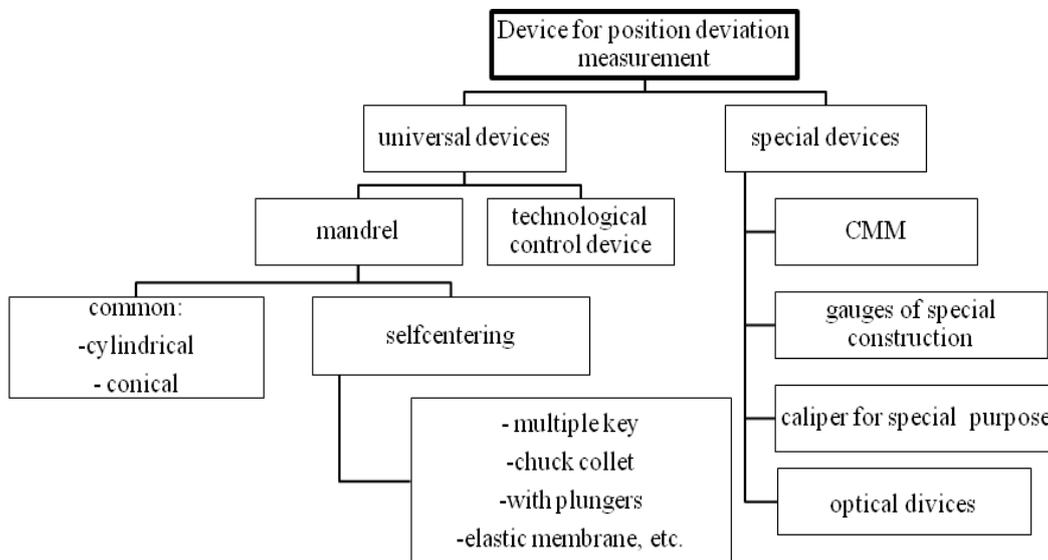


Figure 1. Diagram for position deviation measurement devices

A variant of the position deviation measuring (nominal position) using universal measuring instruments involves using a testing mandrel what materializes adjacent cylinder. The workpiece will be placed in a device with self centering peaks. The contact between the testing mandrel and indicating instrument can be controlled by an equal arms lever. The generalization can be increased for the common mandrels further by performing sets of interchangeable plungers, but the price increases in this case and does not solve the problem of intermediary control of keyways, in small series production.

2 SOLUTION FOR THE POSITION DEVIATION MEASUREMENT

2.1 Theoretical consideration

The deviation from symmetry of the keyway hub is an important element and for him one can prescribe individual tolerance, because together with the deviation from the symmetry of the keyway shaft, one can make possible or not the assemble shaft – hub ensuring proper joint (Mircea, 2004; Sturzu, 1977). The analysis of the methods and means of symmetry deviation control of the keyway hub must meet the following conclusions:

- the precise measurement methods using the stationary control devices are difficult to

implement and requires a number of accessories and complex and expensive measuring tools;

- the measurement methods applied using portable instruments do not provide an adequate accuracy in most situations and are time consuming regarding the adjustment, the measurement and the measurement results processing.

Given these conclusions, the paper objective was to establish a schematic diagram of the control device so that in order to to eliminate these highlighted drawbacks and to combine the advantages of portable devices equipped with precise indicator instruments characterized by high accuracy of measurement. In the production lines case, one can chose the CMM (Coordinate Measuring Machine), but in limited production series, this method is expensive and time consuming (Manarvi, & Juster, 2004) and isn't an appropriate one for small enterprises. Some solutions to the symmetry measurement are the devices presented in this paper.

In order to design the control device, there was established a method of measuring the symmetry deviation of the internal keyway related to the plane that passes through the axis of rotation of the hub (the symmetry plane of the joint), on which a schematic diagram of the device that is the measurement scheme was drawn.

The first measurement scheme of the proposed control device is presented in Fig. 2. The symmetry

plane of the joint coincides with the vertical plane A-A passing through the rotation axis of the inner surface of the hub; the adjacent surface is materialized in three support point by means of the probes 1, 1' and 1'', which come into contact with the inner cylindrical surface of the hub and can move with the same distance in the radial direction.

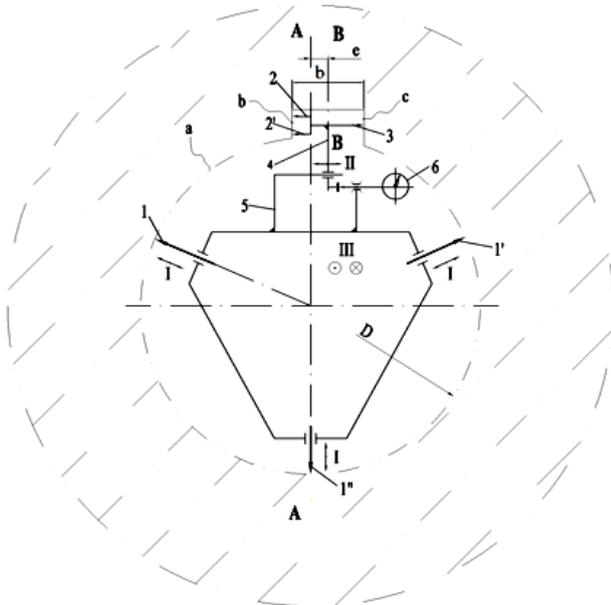


Figure 2. The measurement scheme for the workpieces diameter between 30-80 mm

The symmetry plane B-B materialization of the keyway is achieved through the detecting elements 2, 2' and 3, as follows: the detecting elements 2 and 2' are brought into contact with one surface-surface b, and feeler 3 is in contact with the other surface c; all the three probes are connected each other and are mounted on both sides, equally spaced, to a support 4, which moves on the fixed guide rail 5. The moving of the support (4) is transmitted directly without amplification to the instrument indicator (6).

The other measurement scheme is presented in Fig.3. The deviation from the symmetry of the keyway of the hub workpiece (the eccentricity) is the distance e , between the plane of symmetry P-P of the keyway and the second symmetry plane of the joint, respectively the hub (Fig. 3.a, the side view and 3.b, front view).

For the eccentricity measurement, it is necessary to materialize the symmetry plane (P-P) of the keyway; this is achieved by the axis of mobile plunger (1), that comes in contact with both side surfaces a and b of the keyway.

This mobile detecting element is mounted on a sled (2) with rectilinear motion in order to send the measurement information at the indicator instrument (3).

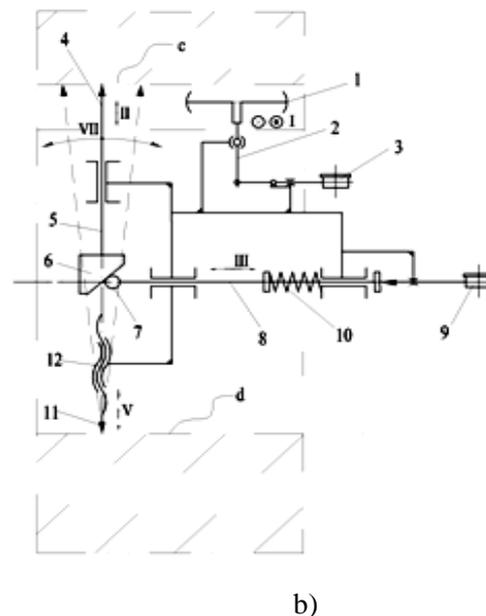
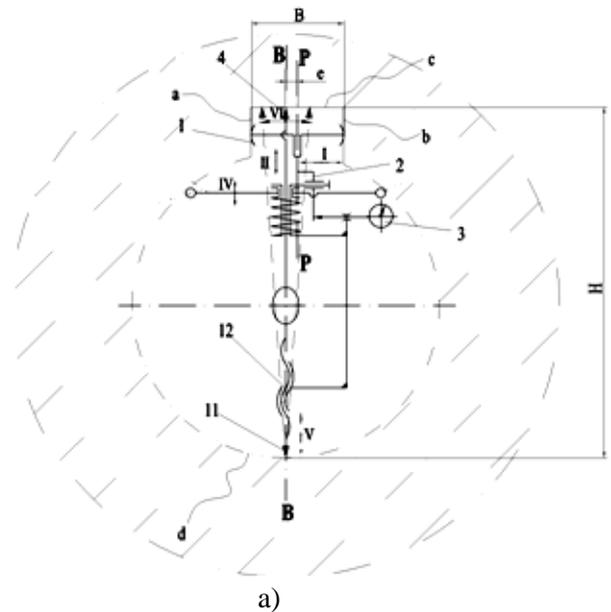


Figure 3. The measurement scheme for the workpieces diameter between 80-150 mm

The materialization of the symmetry plane is carried by a mechanism made up of two coaxial probes, one fix during the measurement, the other as ball type; detecting element 4 is brought into contact with the flat surface c of the bottom keyway. It performs a linear movement II, which is transmitted to the indicator instrument (9), changing the direction by 90° , via a ramp mechanism (5, 6,

7, 8). The compression coil spring (10) ensures the permanent contact between the transmission elements. The stationary detecting element (11) is based on the lowest generatrix of the internal cylindrical surface *d* of the hub; a screw mechanism 12 controls the movement IV, so that it provides the values for the parameter H.

2.2 The constructive solution

Based on the measurement scheme (Fig. 2), there have been developed and designed two versions of the technological devices for controlling deviations from symmetry keyways. The Fig. 4 presents a constructive solution of the first device for controlling the symmetry deviation of hub keyways with diameters of 50-80 mm. This control device has the following structure: the orienting - positioning subassembly, the measuring subassembly and the device body.

The control device, being portable, is guided and pressed against the inner cylindrical surface of hub

by means of four probes support (1), cylindrical type, whose extreme generator *b*, materialized by the effective diameter of the adjacent cylindrical surface of the hub. One of the support probe cylindrical rollers type is mounted at one end of the rectangular blades (2), which moves on the guides of the same shape, in the body of the device (5). At the other end of this blades, there are fitted contacts rollers (not shown) which are based on the conical surface of the adjuster (not shown). The adjusting rod can be moved axially by means of a screw mechanism, and determines the movement on radial direction of the support rollers that ensure a range of values for the diameter of the adjacent cylinder materialized by the generator of probes support. The axially moving of the adjusting rod is made by turning the knurled end (4) thereof. The four probes supports are maintained grouped by the spring ring (11).

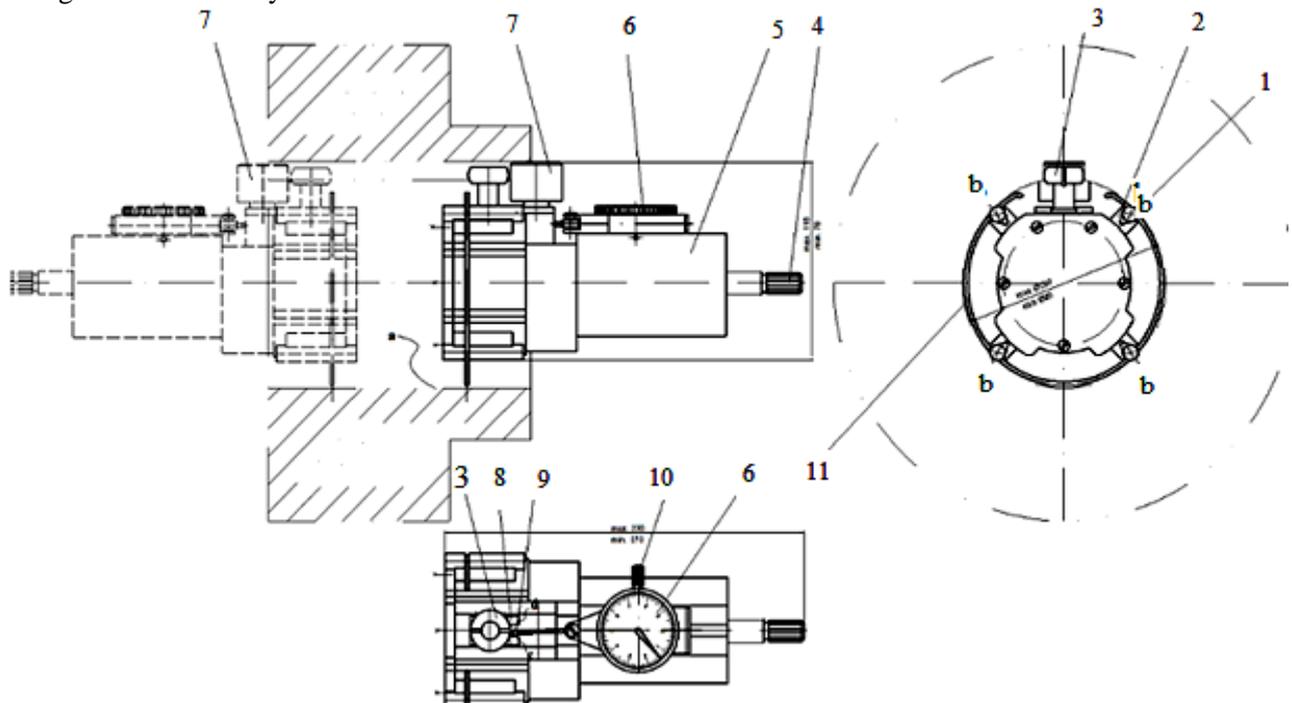


Figure 4. Device for symmetry deviation measurement for hub with diameter between 50 and 80 mm

The capture probe, a mobile one, is an elasticized sleeve (3), which is in contact with the side surfaces of the keyway of the hub. This elasticized sleeve is fixed to a slide (8), which moves on guides fitted in the cylindrical body of the control device. The moving of the slide is transmitted to the probe (9), ball type, of the indicator instrument (6). This probe is in contact with one of the two surfaces *c* and, respectively *d*, of the slide. In order to measure the symmetry

deviation of the hub keyway, it is necessary to materialize the plane of symmetry of the keyway.

This aspect is achieved by means of a cylindrical roller -shaped element (7), mounted on the device body by the threaded connection, such that its axis coincides with the vertical symmetry plane of the hub. The diameter of the roller (7) is higher than the width of the controlled keyway and edges are brought into contact to the front edges of the hub keyway.

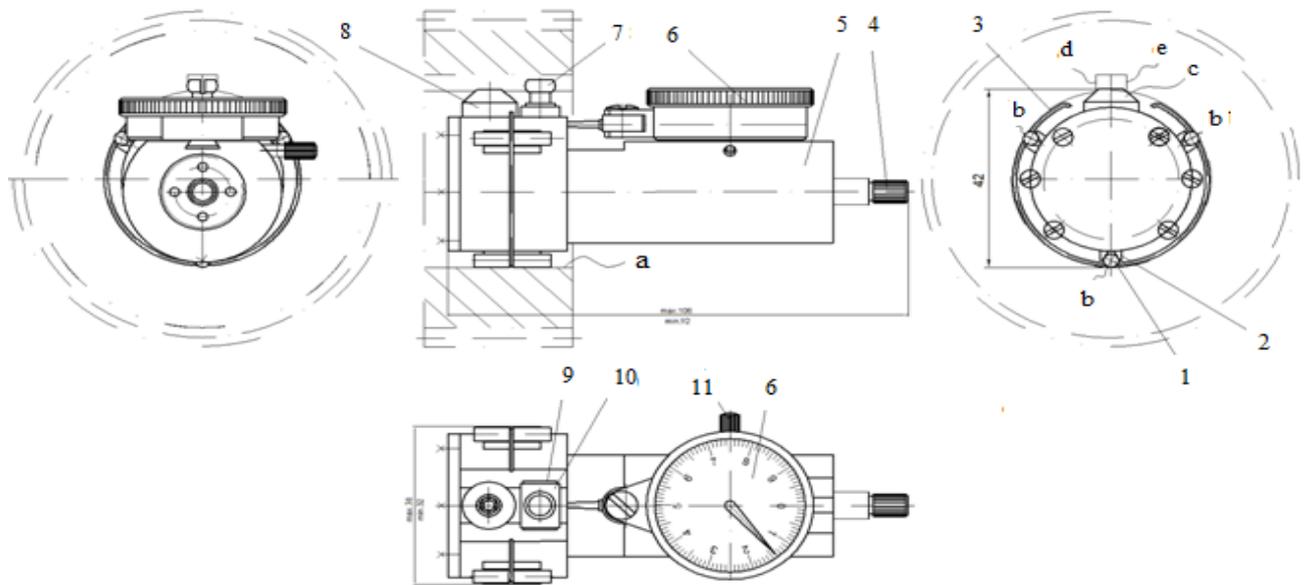


Figure 5. Device for symmetry deviation measurement for hub with diameter between 30-50 mm

The second control device (Fig. 5) has generally the same notation like the device presented in Fig. 4. The differences are given by the measurement subassembly. For the measurement of the symmetry deviation of the hub keyway, it is necessary to materialize the plane of symmetry of the keyway; this is achieved by means of a cylinder roller element 8, that has at the end a conical surface *c*. This roller, also referred to as the index, is mounted to the device body so that it can move in the radial direction, being pushed towards the keyway by the force developed by a compression coil spring (not shown), so that the

indexer is always in contact with the longitudinal edges *d* and *e* of the keyway and the axis (which, by its structure coincides with the vertical symmetry plane of the hub) will be in the plane of symmetry of the keyway.

The two devices have the same scheme in principle, but they present different ways of seeing the adjacent cylinder (with 3 and 4 measuring elements), different solutions for indexing element to the plane of symmetry of the keyway, different solutions for mounting and moving the mobile probe and different solutions to ensure contact probes support-rod adjustment.

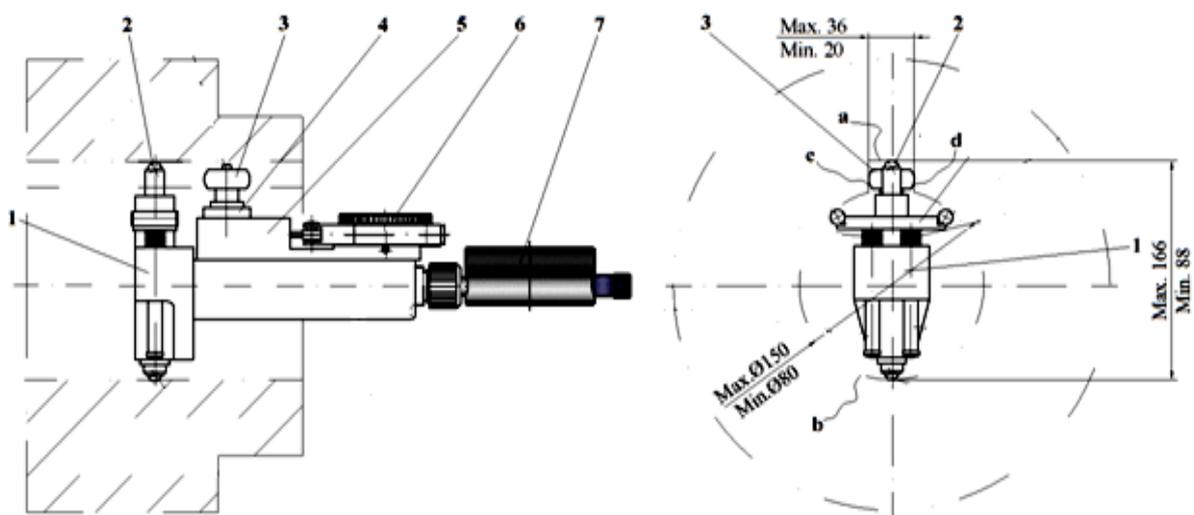


Figure 6. Device for symmetry deviation measurement for hub with diameter between 80-150 mm

Another possibility is given by the third control device (Fig. 6); this device has in his structure compared to the two above presented, the subassembly of measuring the eccentricity and the subassembly for depth keyway measurement.

The detecting element is an elasticized interchangeable sleeve (3), which is in contact with the side surfaces a and b of the hub keyway. The elasticized sleeve is fixed to a carriage (4), with cylinders guides mounted in the holder (5), wherein is mounted an indicator (6). The moving of the slide is transmitted to the probe ball of the indicator instrument. The measurement is achieved by means of a conical indexer, which is inserted in a conical recess of the cylindrical body of the device. The other components are similar to those outlined in the cases of the first two devices.

3 CONCLUSIONS

The dimensional control of the products is a key factor in any machining system and it is provided by a separate component integrated in the production system which is basically a technological control device. The dimensional control can be achieved during the *machining* process between the different stages and processing operations, as intermediary control or during the final control. So that, the intermediary control or process control is achieved with the specific control devices that are part of the technological equipment control. A theoretical analysis was developed in order to identify the measuring possibility of symmetry and nominal position deviation for a specific keyway. The authors solution is adequate for small enterprises which cannot afford to invest money in coordinates measuring machine. Among the requirements which the device conceived and designed must satisfy, it is shown that a number of its elements are characteristic of a processing technological device. It can be considered, therefore, that this project could be included into the category of technological control devices integrated into processing technology keyways for workpiece bore type.

The principle scheme of the all three devices proposed in the paper offer solutions for the indexing element, for the contact probes support-rod adjustment and increases the measurement field,

so that one can measure a rather large range of diameters, between 30 mm and approximately 150 mm and these values respect the portability condition. The device ensures a sufficient values range of the diameter of the hub (adjusting solution) and, in the same time, the width of the keyway (interchangeable elasticized feelers solution). The third control device provides the ability to measure, in addition to position deviations measurement, the keyway depth, through an additional dial gauge.

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