SHAFT DEPTH MEASUREMENT BY MEANS OF AN ELECTRO-OPTICAL DISTANCE METER

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The need for up-to-date means of measuring shaft depths raised the problem of measuring vertical distances by electro-optical instruments.

In this country, the first relevant tests are going on, however, with rather promising results, worth of being presented.

For measuring a vertical distance, the electro-optical distance meter is required

— to project the measuring light beam into the shaft;
— to project the beam with a perfectly vertical axis into the shaft;
— to provide for a possibly horizontal and central position of the reflecting prism on the shaft foot.

There are two ways of meeting the first two requirements, depending on the instrument type, both having in common that the instrument will be set up directly on the platform of the shaft collar. They differ by the way of making the beam vertical. Either the instrument is set up and fixed, turned by 90° on its tripod. Now, the beam gets directly into the shaft, without an optical aid.

Or the instrument is fixed in normal position on its tripod, and the about horizontal beam is reflected by a mirror mounted on the objective socket at 45° to the objective plane and projected into the shaft. In this case, the distance excess due to the mirror has to be reckoned with as an addition constant determined in laboratory tests. The direction is made vertical by means of a level.

Remind, however, that sometimes the fittings in the shaft prevent the prism from being centered beneath the instrument, hence, the depth measurement from being vertical.

Examination of the source of error due to prism excentricity led to the finding that the error was below 5 mm if the angle included between the beam and the vertical was less than the α values vs. depth H compiled in Table 1; or if the prism excentricity was less than the x values tabulated as a function of H.

Table 1

H (m)	α	x (m)
	° ′ ″	
100	0—34—20	1.00
500	0—15—20	2.23
1000	0—10—50	3.15

In establishing the max. 5 mm error component, tolerance admitted in the mining survey directives actually in force in this country, the permitted error in the use of a physical distance meter being:

$$\Delta H = (0.01 + 0.0001\, H)\ [\mathrm{m}],$$

where H is the depth in m to be measured.

In Hungary, few shaft depth measurements applied an electro-optical distance meter to now. In October 1972, the *Institute of Geodesy, Surveying and Cartography* applied a Wild Distomat type DI-10 IR beam distance meter in a shaft about 250 m deep under construction. The parted construction of distance meter DI-10 (ray emitter separate from measurement unit), its low weight and small volume makes it handy in central setup. For vertical distance measurement, the instrument has to meet a special requirement: the prism should be in a nearly vertical plane determined by the two optic axes of the measurement unit, normal to its longer symmetry axis.

To meet requirements, accessories had to be constructed for the instrument DI-10.

A special tripod was made (Fig. 1), with a head permitting the DI-10 measurement unit to be fixed with optical axis pointing down and adjusted by means of bottom screws. Sighting was facilitated by an auxiliary telescope mounted on the measurement unit.

In course of the measurement, first the prism with its tripod was placed in the elevator cage with opening cover, and let down. Thereafter an instrument station and an independent observing station have been built on the shaft collar. Initially, sections of the entire depth have been measured. There exist no comparative data for these section lengths, only agreement between repeated measurement data may be considered as a checking. Sectional measurement was imposed by the need to observe atmospheric conditions (in particular, to evaluate the vapour content and its effect on distance measurement).

Measurement observations and results can be recapitulated as follows:

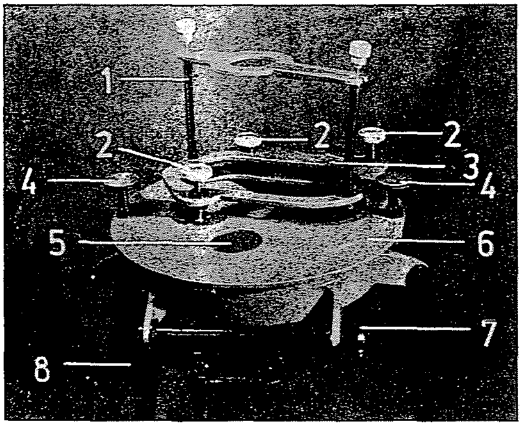

Fig. 1. 1 — fastening springs; 2 — tilting screws; 3 — holding plate; 4 — horizontal clamp; 5 — place for auxiliary telescope; 6 — tripod head; 7 — tripod screw; 8 — tripod legs

For depths of 25 m, 41 m and 70 m, out of the three prisms of the instrument DI-10 a single one had been left open, the other two were covered. Signal intensity was 9. Trickling water was insignificant.

At 150 m depth, use of the entire triple prism surface resulted in a signal 9 in the first measurement, while in the third repetition the signal strength dropped to 4 due to trickling water and vapour.

At the full depth of 213 m, immediately after starting to sight, the signal had an intensity of 9, but in repetition the trickling water formed a continuous film on the prism surface, further reducing the signal intensity to 2. The fine reading circle of the instrument oscillated around ± 2 cm. The average mean square error calculated from the differences referred to conventional tape measurements was $\pm 15{,}4$ mm, the permitted error being 30 mm.

In 1973, the *Laboratory of the Institute of Geodesy, Technical University, Budapest*, made shaft measurements by means of a distance meter type Geodimeter 6 of the AGA Co.

The reflecting surface was a group of 17 prisms type EOK-2000 screwed onto a steel plate to be placed at the depth to be measured, on the walking platform.

The shaft was about 700 m deep, with pump chambers each 200 m. The problem was to determine the shaft floor depth and to check the existing elevations at each level. Because of the showering water, measurement arrangement was the reverse as usual. The prisms have been placed on the shaft collar with the reflecting surface pointing downwards, and the distance meter on the shaft floor, with its telescope pointing vertically upwards. The objective of small diameter was likely to be exposed to less water than the prisms of rather large surface, hence easier to keep dry. This arrangement did not permit, however, to measure a section deeper than 100 m. This distance could be measured twice in 15 min, at a difference of 4 mm.

This arrangement proved, however, to be inconvenient, since water that dropped in the objective socket with its impurities coated the objective, inhibiting it to be wiped dry and clean, it being anyhow next to inaccessible for cleaning.

Back to the original arrangement, the laboratory constructed a lid to protect the prisms (Fig. 2). It consisted of a horizontal plastic disk kept in fast rotation (300 to 500/rpm) by a motor in the steel prism-holder plate

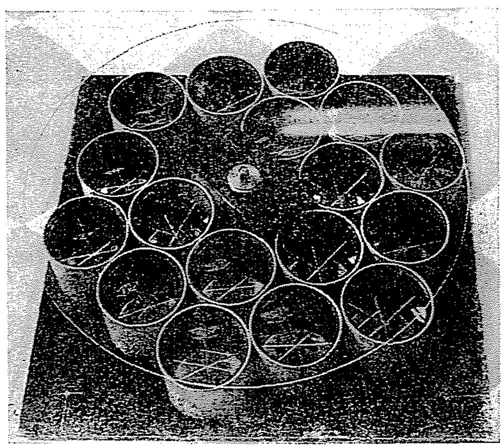

Fig. 2

center. Water dropping on the rotating plastic disk was expelled by the centrifugal force, eventual adherence of drops was prevented by a coating on the disk surface, making it self-cleaning.

The 4 mm plate thickness did not prevent parallel beams from being transmitted, the optical path difference being less than 2 mm.

To maintain verticality of the Geodimeter telescope with its objective pointing downwards, the distance meter was mounted on the girotheodolite tripod turned by 90°, since here an adequate opening was left to the telescope. The instrument was fastened by springs to the tripod head (Fig. 3). The distance meter objective was protected to vapour condensation by a tube mounted on the telescope.

The presented equipment was tested by measuring a shaft 900 m in depth. The distance meter was placed on the shaft collar, and the prisms on the shaft floor. Telemetry results have been compared with previous tape measurement results, yielding a difference of 48 mm, telemetry results being the shorter. Permitted error is 100 mm.

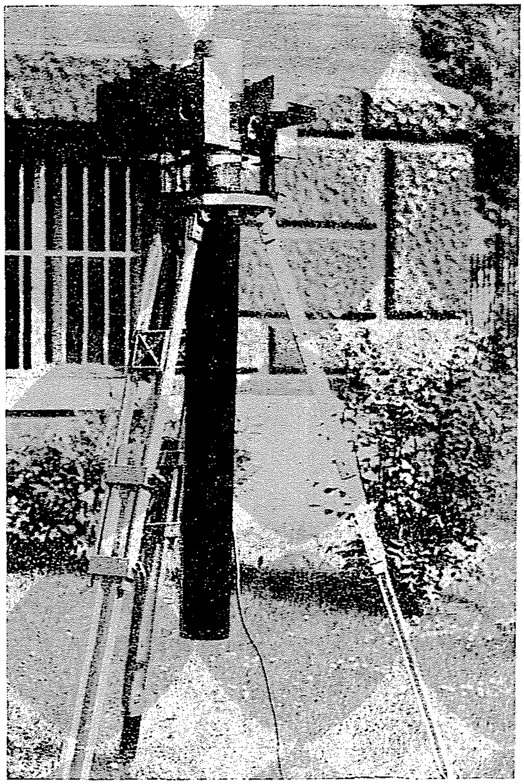

Fig. 3

Our experimental measurements are continued in the conviction that actual difficulties will be eliminated and this up-to-date method of shaft measurement will become a routine practice.

Summary

Results of experimental shaft length measurements carried out with a Wild short-range distance meter DI-10 and an AGA medium-range distance meter Geodimeter 6 are reported on. A complementary device had to be installed in order to keep the measuring beam in vertical position and to protect the prisms and instrument optics to humidity. The EDM measurements were compared every time with previous tape measurements: the measurement of 213 m distance with DI-10 resulted in an average mean square error of ± 15.4 mm and over 900 m, the AGA Geodimeter gave a 48 mm shorter distance than did a tape.

References

1. Milasovszky, B.: Possibilities of Low and Medium Range Physical Telemeters in Hungarian Mine Measurements. Symposium for Telemetry, Sopron, 1971.
2. Meixner, A.: Erfahrungen beim Einsatz elektrischer Streckenmeßgeräte im Bergbau. Proceedings of the International Conference on Mine Measurements, Budapest, 1972.

3. MÖLLER, D.: Schachtteufenmessung mit dem Geodimeter. Allgemeine Vermessungsnachrichten 1966/1.
4. SCHMIDT, D.: Erfahrungen beim Einsatz von schlagwettergeschützten elektrooptischen Entfernungmessern unter Tage. Proceedings of the International Conference on Mine Measurements, Budapest, 1972.
5. SCHUBERT, B.—LOZENZ, G.: Einsatz des elektrooptischen Streckenmeßgerätes EOS des VEB Carl Zeiss Jena für Teufenmessungen hoher Genauigkeit. Neue Bergbautechnik H. 1. 1971.

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