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SURVEYING THEODOLITE BETWEEN PAST AND FUTURE

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Abstract

Surveying instruments have evolved over time since the 19th century until present. One of the surveying instruments is the theodolite. A theodolite is a precision instrument for measuring angles in the horizontal and vertical planes. The paper aims to highlight the improvements made over time on this instrument in constructive and operational terms.

***Key words**: surveying,evolution,theodolite.*

INTRODUCTION

Prior to the theodolite, instruments such as the geometric square and various graduated circles and semicircles were used to obtain either vertical or horizontal angle measurements. It was only a matter of time before someone put two measuring devices into a single instrument that could measure both angles simultaneously. GregoriusReisch showed such an instrument in the appendix of his book Margarita Philosophica, which he published in Strasburg in 1512(Maurice D., 1989). It was described in the appendix by Martin Waldseemüller, a German topographer and cartographer, who made the device in the same year.Waldseemüller called his instrument the polimetrum.

The first occurrence of the word "theodolite" is found in the surveying textbook A geometric practice named Pantometria (1571) by Leonard Digges.

There is some confusion about the instrument to which the name was originally applied. Some identify the early theodolite as an azimuth instrument only, while others specify it as an altazimuth instrument. In Digges's book, the name "theodolite" described an instrument for measuring horizontal angles only. He also described an instrument that measured both altitude and azimuth, which he called a topographicall instrument. Thus the name originally applied only to the azimuth instrument and only later became associated with the altazimuth instrument. The 1728 Cyclopaedia compares "graphometer" to "half-theodolite"(Cyclopaedia, vol. 2).Even as late as the 19th century, the instrument for measuring horizontal angles only was called a simple theodolite and the altazimuth instrument, the plain theodolite.

The first instrument more like a true theodolite was likely the one built by Joshua Habermel (de:ErasmusHabermehl) in Germany in 1576, complete with compass and tripod.

Figure 1. Eight-inch theodolite, c. 1898

The earliest altazimuth instruments consisted of a base graduated with a full circle at the limb and a vertical angle measuring device, most often a semicircle. An alidade on the base was used to sight an object for horizontal angle measurement, and a second alidade was mounted on the vertical semicircle. Later instruments had a single alidade on the vertical semicircle and the entire semicircle was mounted so as to be used to indicate horizontal angles directly. Eventually, the simple, open-sight alidade was replaced with a sighting telescope. This was first done by Jonathan Sisson in 1725.

Figure 2. Soviet theodolite, 1958

The theodolite became a modern, accurate instrument in 1787 with the introduction of Jesse Ramsden's famous great theodolite, which he created using a very accurate dividing engine of his own design(Turner 1983).The demand could not be met by foreign theodolites owing to their inadequate precision, hence all instruments meeting high precision requirements were made in England. Despite the many German instrument builders at the turn of the century, there were no usable German theodolites available. A transition was brought about by Breithaupt and the symbiosis of Utzschneider, Reichenbach and Fraunhofer. As technology progressed, in the 1840s, the vertical partial circle was replaced with a full circle, and both vertical and horizontal circles were finely graduated (Figure 1). This was the transit theodolite. Theodolites were later adapted to a wider variety of mountings and uses. In the 1870s, an interesting waterborne version of the theodolite (using a pendulum device to counteract wave movement) was invented by Edward Samuel Ritchie. It was used by the U.S. Navy to take the first precision surveys of American harbours on the Atlantic and Gulf coasts.

In the early part of the 20th century, Heinrich Wild produced theodolites that became popular with surveyors (Figure 2). His Wild T2, T3, and A1 instruments were made for many years, and he would go on to develop the DK1, DKM1, DM2, DKM2, and DKM3 for Kern Aarau company. With continuing refinements instruments steadily evolvedinto the modern theodolite used by surveyors today (Figure 3).

Figure 3. Modern theodoliteNikon DTM-520

MATERIALS AND METHODS

Parts of a Theodolite

Like other leveling instruments, a theodolite consists of a telescope mounted on a base. The telescope has a sight on the top of it that is used to align the target. The instrument has a focusing knob that is used to make the object clear. The telescope contains an eyepiece that the user looks through to find the target being sighted. An objective lens is also located on the telescope, but is on the opposite end as the eyepiece. The objective lens is used to sight the object, and with the help of the mirrors inside the telescope, allows the object to be magnified.

The theodolite's base is threaded for easy mounting on a tripod (Figures 4 and 5).

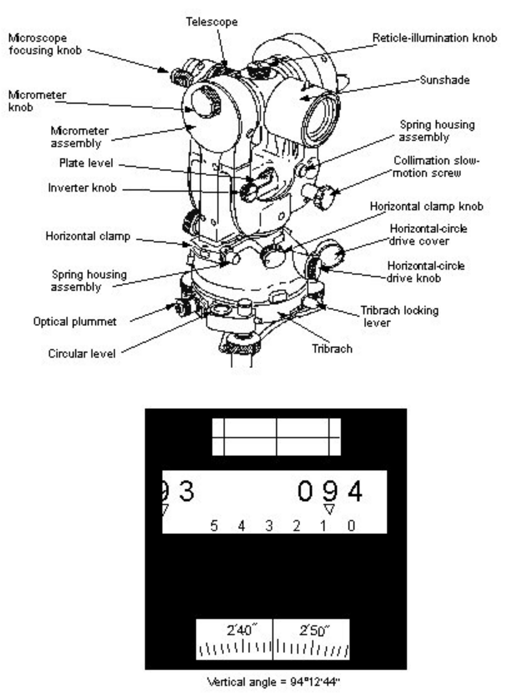

Figure 4. Diagram of an Optical Theodolite

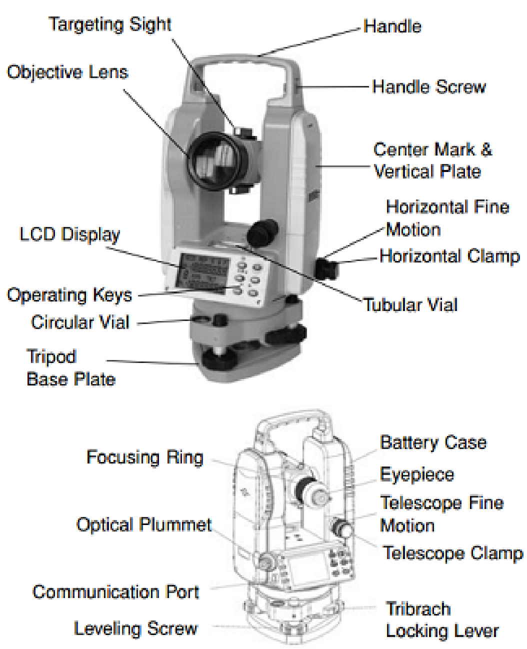

Figure 5. Diagram of an Modern Theodolite

How Does a Theodolite Work?

A theodolite works by combining optical plummets (or plumb bobs), a spirit (bubble level), and graduated circles to find vertical and horizontal angles in surveying. An optical plummet ensures the theodolite is placed as close to exactly vertical above the survey point. The internal spirit level makes sure the device is level to the horizon. The graduated circles, one vertical and one horizontal, allow the user to actually survey for angles.

How to use a theodolite:

1. Mark the point at which the theodolite will be set up with a surveyor's nail or a stake. This point is the basis for measuring angles and distances.
2. Set up the tripod. Make sure the height of the tripod allows the instrument (the theodolite) to be eye-level. The centered hole of the mounting plate should be over the nail or stake.
3. Drive the tripod legs into the ground using the brackets on the sides of each leg.
4. Mount the theodolite by placing it atop the tripod, and screw it in place with the mounting knob.
5. Measure the height between the ground and the instrument. This will be used a reference to other stations.
6. Level the theodolite by adjusting the tripod legs and using the bulls-eye level. You can make slight tunings with the leveling knobs to get it just right.
7. Adjust the small sight (the vertical plummet) found on the bottom of the theodolite. The vertical plummet allows you to do ensure the instrument remains over the nail or stake. Adjust the plummet using the knobs on the bottom.
8. Aim the crosshairs in the main scope at the point to be measured. Use the locking knobs on the side of the theodolite to keep it aimed on the point. Record the horizontal and vertical angles using the viewing scope found on the theodolite's side.

RESULTS AND DISCUSSIONS

Theodolites have many advantages when compared to other leveling instruments:

- Greater accuracy.
- Internal magnifying optical system.
- Electronic readings.
- Horizontal circles can be instantly zeroed or set to any other value.
- Horizontal circle readings can be taken either to the left or right of zero.
- Repeat readings are unnecessary.

Theodolites have an internal optical device that makes reading circles much more accurate than other instruments.
Also, because the theodolite allows you to take fewer repeat readings, these measurements can be made much more quickly. Theodolites with optical instruments have advantages over other layout tools. They have more precise measurements, they are unaffected by wind or other weather factors, and they can be used on both flat ground and sloped ground (Figure 6).

Figure 6. Theodolites evolution

NIKON NE-20S ELECTRONIC THEODOLITE (Figures 7,10)

Magnification: 26X.
Image: Erect.
Minimum focusing distance: 1.3m/4.3'.
Angle accuracy: 10"/3 mgon.
Angle minimum display reading: 10"/20".
Angle detecting system: Dual-side reading.
Angle units: Switchable between degrees or gon.
Optical plummet: Erect 2.2X.
Weight: 3.8kg, 8.4lbs including tribrach and battery.

CARL ZEISS THEO 020 B (Figures 8, 9)

Average error of measurement - two positions of the telescope 1 mgrad (3 ").
Zoom: 30 times.
View Angle: 1,3 °.
Looking A distance of 1 km 23 m.
Minimal Referred to 1,5 m away.
Maximal Sight distance when using the rack with inch graduations:

- 120 m.
- Rules evaluation with precision 0.5 cm 500 m.
- Permanent Multiplier 100.
- Angular error of the cylindrical vial.
- Displacement of the bubble of 2mm 30".
- Interval of graduation grad 1.

The value of the division in the reporting scale 10 mgrad.

Figure 7. Nikon ne-20s electronic theodolite

Figure 8. Carl Zeiss Theo 020 b

Figure 9. Optical theodolite

Figure 10. Electronic theodolite

CONCLUSIONS

This study was conducted to highlight the evolution of surveying instruments over the years. Our study demonstrates that people have managed to achieve the dream from decades ago by bringing innovations to old equipment and they manage to make our work increasingly easier.

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