

Appendix Three

Brief History of Ancient Surveying Practices

The following pages trace the development of general surveying technologies and techniques from Ancient Egypt until approximately the thirteenth century.

Surveying has a long history originating in Egypt some 3400 years ago (in approximately 1400BCE). Herodotus tells us that the Egyptian king Sesostris (who may actually have been an amalgamation of several pharaohs) divided his kingdom into plots in order to organize taxation (Histories, Book II, Lines 100-182). This system was complicated by the frequent flooding of the Nile, and resulted in routine re-measuring of plots by appointed *rope-stretchers* who were so named because they used ropes with distances marked by knots on them to re-establish the plots. This system inspired Greek thinkers to invent geometry. Nearly one thousand years after Sesostris instituted his system of land plots a Greek scientist named Heron wrote perhaps the first surveying text in the world, *The Dioptra*.

Heron's work, *The Dioptra*, outlines methods for surveying fields, drawing plan views, and making the related calculations (Lewis 2001: 51-52). The many inventions of Heron (including the first steam engine and the odometer) includes a device for measuring distances called a dioptra (Fig 3-3) not to be confused with the measurement of focus used in optics. This simple machine allows users to correctly measure angles between points by applying principles of triangulation, as well as adjust for slope by tilting the plane. In effect, this instrument behaved like the 16th century telescopic theodolite developed by the English mathematician Leonard Digges. Heron outlined a potential use for this machine in his *Dioptra*, which used triangulation and a dioptra to tunnel through a mountain (Fig 3-4). In short, the process of using the dioptra to tunnel was to select a point close to the first entrance (B) and another point (E). Then use the dioptra to obtain a perpendicular line (EF) and continue measuring perpendicular line segments (FG, GH, HK, and KL). Then a final perpendicular line off of line KL to the

other entrance point (D). Finally, a surveyor could calculate the angle necessary for tunneling through points B and D in order to insure that the tunnel lined-up inside the mountain. This process is the same today; however lasers and computer guided surveying instruments are used instead of line-of-site instruments such as Heron's dioptra.

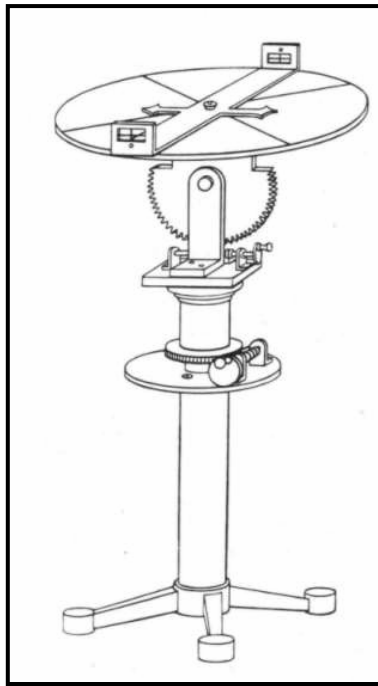


Figure App03-01: Reconstruction of Heron's dioptra from Teubner

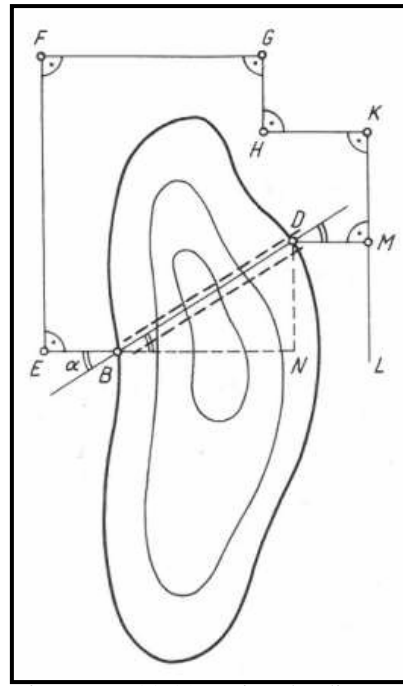


Figure App03-02: Using the dioptra to tunnel

The next major advancement in surveying came from the Roman scientist Frontinus, demonstrated by the complicated feats of engineering evident throughout the Roman Empire. A contemporary of Heron, Frontinus lived around 79CE and was *curator aquarum* (water commissioner) for the Empire. He developed ingenious surveying instruments; the *groma*, *libella*, and the *chorobates*. The *groma* (fig 3.5) was simply two pieces of wood crossed and supported by a single post, with plumb bobs hung from each of the four spokes and a fifth hung near the center. It was designed to survey straight lines and right angles (Lewis 2001: 125). *Groma* parts have been recovered from numerous archaeological sites, including metal plumb bobs used by a surveyor named Verus from

Pompeii currently housed in the Science Museum, London. The *libella*, or a-frame level (fig 3.6), was simply an a-frame made of wood with a plumb bob suspended from the top of it used to level objects such as buildings and earthen structures. The *chorabates* (fig 3.7) was used to site horizontal reference along its top edge. It consisted of a long straightedge (sometime up to 20ft or more) with supporting legs and a water-filled groove on top that acted like a spirit-level.

In essence, the basics of surveying were worked out, understood, and implemented by the Greeks and Romans. Central to the art of geomatics was an understanding of geometry and the creation of instruments that allowed for the measurement and placement of points on the ground that corresponded with the mathematical principles that governed geometry. The principles and tools outlined above changed little during the Roman Empire or following its collapse in the 6th century CE. As Europe entered the Middle Ages, and lexicons were destroyed or lost, the Arab world took over custody of these principles (Wolf & Ghilani 2002: 5).

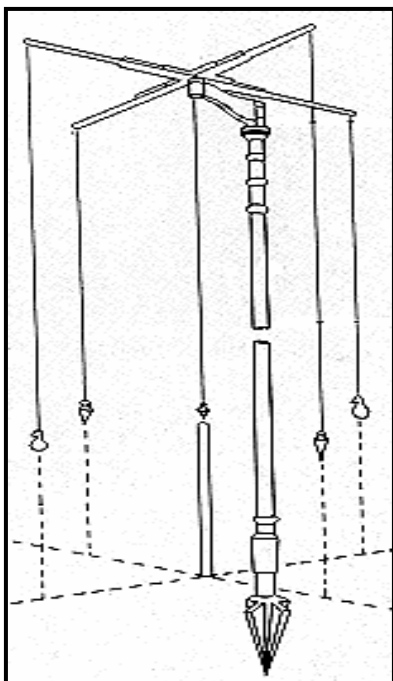


Figure App03-03: A *groma* from Dilke, 1971.



Figure App03-04: MTU Peace Corps volunteer Kristen Rahn uses an a-frame level in Paraguay in 1999.

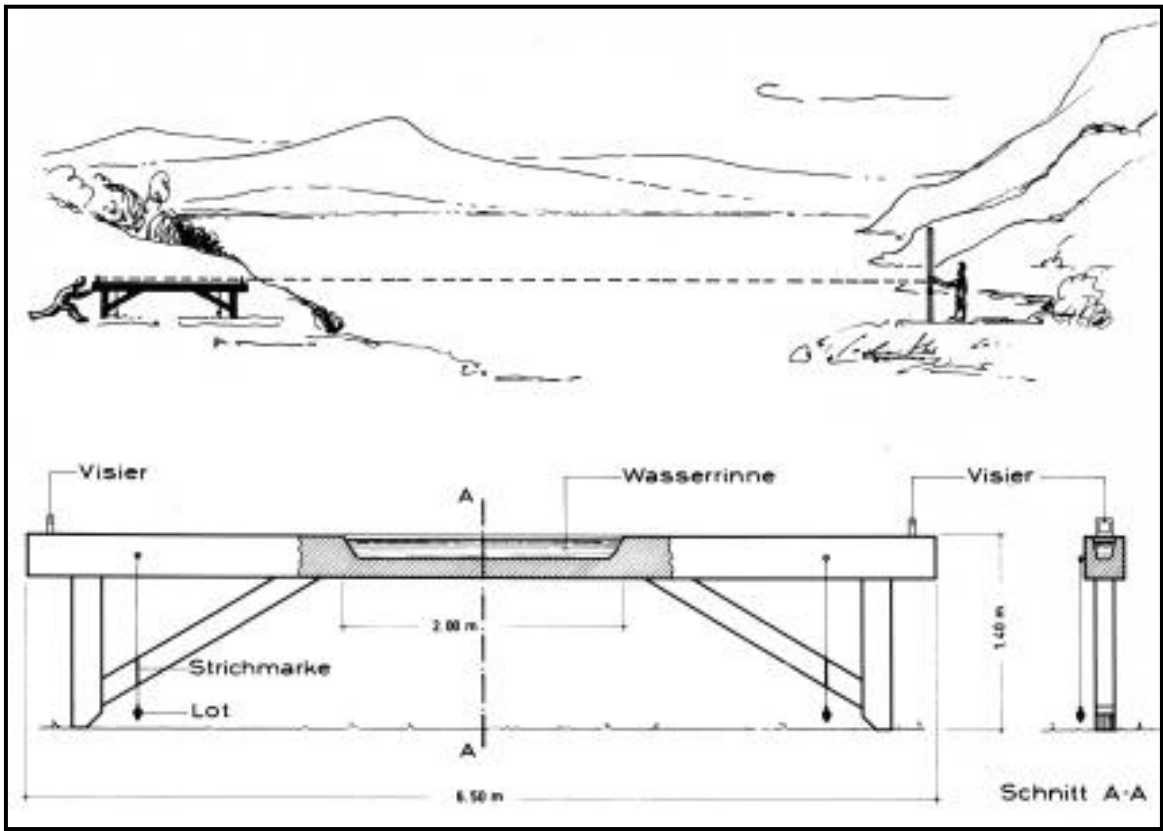


Figure App03-05: Drawing of use and design of Roman *Chorobates* from a 19th century German technological treatise on surveying.