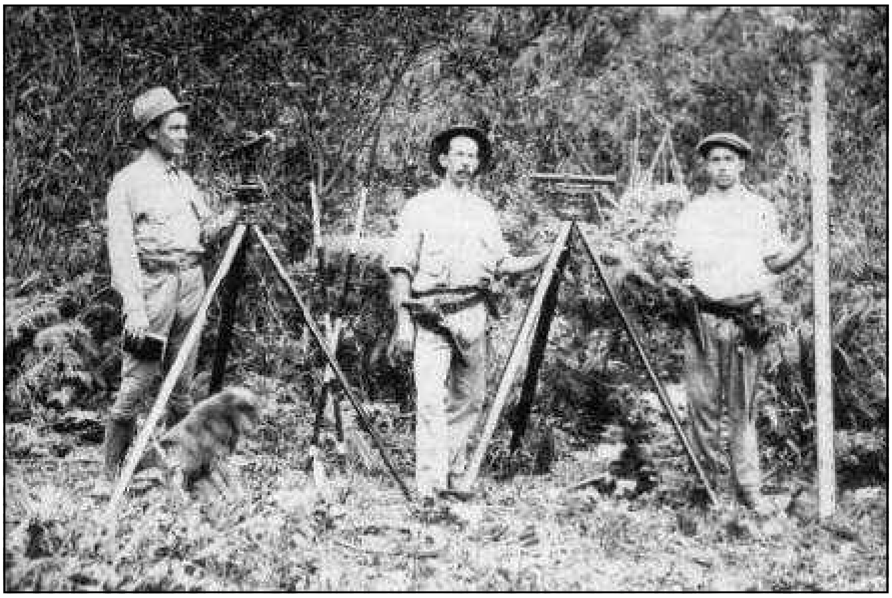
SURVEYING INSTRUMENTS (Part1)

INTRODUCTION

Bernie Hannan was kind enough to give me an old dumpy level at a recent meeting which was "surplus to his requirements"! This series of articles is a result of that acquisition. I have to tread carefully when expounding on surveying equipment because one of our members (Roger Thorne) is a retired surveyor and he may have some critical comments to make! Never-the-less, I will cover old optical instruments and finish with a brief description of the latest electronic gadgetry.



Let's start with glimpse into the past: An old photograph (about 1900) of an Australian survey team. The group includes the surveyor (with notepad), assistant surveyor (no notepad but armed with a revolver) and chainman (also armed). Their equipment includes a transit theodolite, plane telescopic theodolite, steel tape, level pegs and graduated staff. And a dog.

Figure 1 Australian Survey Team approx 1900

THEODOLITES

Theodolites in their crudest form have been around for yonks (perhaps as early as 1550). They became modern, accurate instruments for measuring horizontal and vertical angles in 1787 when Jesse Ramsden perfected his dividing engine for accurately scribing angles. Advancing from open sight lines, telescopes were introduced to magnify targets. Magnification is generally about X20. The optics in these telescopes were arranged so that an inverted image of the target is brought to focus on the crosshairs (originally fine wires but now more generally etched lines on glass plates). Another Jesse device (the Ramsden Eyepiece) focused on the crosshairs and on the telescopic image. A reference book on survey methods says "It is possible to have an eyepiece that gives an upright image but this needs more lenses: all surveyors soon become accustomed to seeing everything upside-down!".

Early theodolites had external verniers on both horizontal and vertical scales and early in the 1800's "transit" theodolites were developed that allowed the telescope to be "flipped over". Combined with the ability to turn the telescope "about face", the surveyor could correct for instrument errors and accuracy was usually 30 arcseconds or less. The nickname "transit" was also applied to less accurate (and cheaper) plane telescopic instruments (see photo above) which were widely used to open up the railroad network across America. The theodolite shown in Figure 2 was made by W F Stanley & Co, London but is labeled "W McDonnell & Co. Sydney No 159". I bought it on Ebay, of course.

Figure 2 Transit Vernier Theodolite (to be displayed at POP 2013)

The next significant development was optical or microptic theodolites which did away with the need to take readings externally. All the measurements can be read through the telescope but the optics are much more complex (and more rugged) than earlier types as shown in Figure 3.

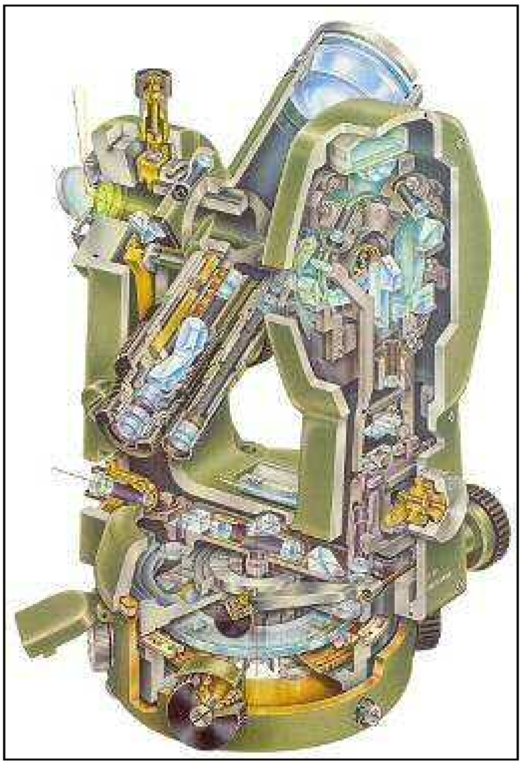


Figure 3 Exploded view of Optical Theodolite showing numerous light pathways that give images of readings to the viewer

SPECIALIST THEODOLITES

There are many specialist theodolites including instruments used in underground mines. I remember seeing stations established underground using "Piano wire" hung down a shaft to establish positions and directions underground where magnetic bearings cannot be relied upon. We had to rub chalk on the wires so that they could be seen. At least we were not trying to do it by candle light!

BALLOON TRACKERS

Theodolites to track meteorological balloons are rather specialized. My instrument is in a box labeled M518/42 Mk II which strongly suggests that it is a product of wartime activity (see Figures 4 and 5).

Figure 4 Wartime picture of a balloon tracking theodolite in action.

Typical of most theodolites, the image is inverted and the crosshairs have numerous horizontal and vertical subdivisions. There are three sighting mechanisms: the first being a simple "gunsight" along the axis of the telescopes. There is a low powered telescope and one of higher power and a simple flick of a lever swaps the viewfinder image from one to the other. There are 2 winders to crank horizontally and vertically and these can be disengaged for rapid movement. The resulting bearings (azimuth and inclination) can be read by the operator by looking down from the eyepiece but also can be read on another scale on the opposite side of the theodolite. A second observer can record details during a balloon release. Usually readings are taken at one minute intervals….this would be a frantic exercise in a high wind! The assent rate of the balloon also has to be established. This could be done by recording how long it takes for a "tail" on the balloon to pass through a theodolite crosshair. More frantic readings!

Figure 5 Theodolite for tracking Meteorological Balloons (to be displayed at POP 2013)

SURVEYING INSTRUMENTS (Part1) - Continued

DUMPY LEVELS

In their elementary form, dumpy levels had a crude telescope and a method of leveling it (the tribranch) so that as it turned through 360 degrees it scribed a horizontal plane. Using graduated staffs the levels at, for example, a building site could be determined accurately. Figure 6 shows an early example with a long sensitive bubble attached to the top of the telescope and four foot screws to set the level. There are no scales to measure vertical or horizontal angles

Figure 6 Elementary Dumpy Level made by Baker and dating from the 1850's

Refinements included a compensating mechanism (see Figure 7) and this is incorporated in Bernie Hannan's example. There is a prismatic "mirror" which hangs like a pendulum. Because of the reflection off the mirror the image viewed was inverted to appear as an upright image. As noted , most other theodolite telescopes generate an inverted image.

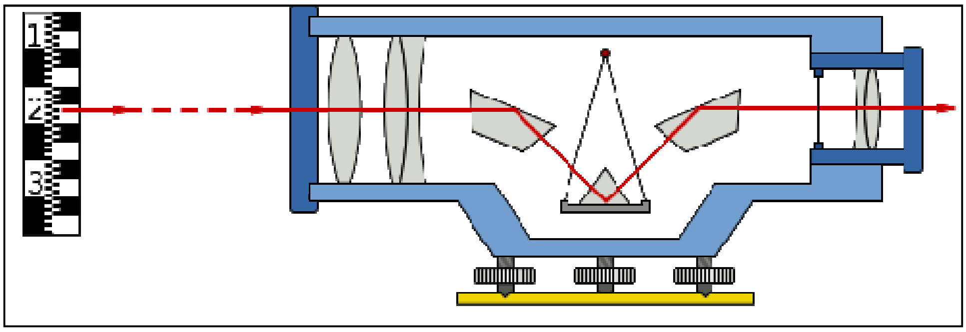


Figure 7 Compensated Dumpy Level, note hanging prism which will reflect a horizontal line of sight.

Figure 8 1950's Ertel Compensated Dumpy Level (gift of Bernie Hannan, take a peep through me at POP 2013)

Next installment will include Alidades, ancillary equipment and the latest developments.

Mark Randell

Stop Press! Dick Turpin has just bought a Theodolite App for his I-Phone (App means Application, if you didn't know). After you set a bearing (for example looking along a north-south road, and registering 0 degrees), the I-Phone camera shows the bearing and inclination as it is turned and tilted, just like a theodolite. Amazing!