Reminisce Of An Old Surveyor, Part II

Measuring Angles & Directions

by
Knud E. Hermansen
P.L.S., P.E., Ph.D., Esq.

I have been surveying for around half a century. When I started surveying the equipment used was little different from the equipment used by surveyors for over 200 years. In fact, many surveyors used the equipment left to them by their grandfathers and fathers. In these present times, I believe most surveyors replace their equipment every ten years or less.

This is the second article on surveying equipment and procedures that are now relegated to history. I believe I am the last generation of surveyors to have practiced the profession using what is now historical equipment and procedures. I believe it helpful for the modern surveyor, when retracing boundaries, to know what the previous surveyor used. Perhaps it will provide a better explanation for the precision of the record measurements and how far to look 'afield' for the monuments after applying the record measurements to the site.

I will say that my first experience measuring directions and angles was as a Marine with the 2nd Topographic Platoon. We used Wild T-2s and even T-3s most of the time. Occasionally, we had to use Wild T16s or transits when doing some construction layout. Once I departed from the Marines and went into private practice, my employers mostly used compasses and transits. One employer did have a theodolite.

Wild T-2s and T-3s were very rare among private surveyors so I will not take up much space on paper discussing these remarkable instruments. The T-2s could measure an angle to the nearest second of arc using a micrometer. The T-3 could measure to the nearest tenth of a second of arc. With the T-3s I have sighted targets almost 30 miles distant. While the T-2s had optical plummets, the T-3s that we used did not. The T-3s required a plumb bob suspended under the instrument in order to put the instrument over the control station. Many of these instruments had an inverted image. What I mean is that the object viewed was upside down when looking through the scope optics. Setting the zero on the instrument required some finesse that I will not describe for the reason I have previously stated.

The common instrument to measure angles and directions at the time I began surveying in private practice was the transit. All surveyors, even the modern surveyor, has probably seen a transit - usually on the table at the historical equipment booth found at the annual professional meeting. Transits can be very handsome with their shined brass or the black and brass contrast.

I did use the compass often, though not the large compass employed by Washington, Lincoln, Jefferson and the other surveyors in the 1700 and 1800s. The compass I employed in years past was a smaller version compass. They were known as the Sipe's compass named after F. Henry Sipe. Henry was licensed surveyor #1 in West Virginia. He was a fine gentlemen that I had the pleasure to know and had many conversations with before his departure from the living.

The compass was used during my early years to perform a reconnaissance to set up the boundary survey and look for evidence in the field. At the time it was thought the best way

to follow in the footsteps of the original surveyor is to use the equipment employed by the original surveyor. I still think this to be true but time constraints of the modern survey practice have curtailed or eliminated much of the reconnaissance practiced in the past using the compass. Of course, using a compass for reconnaissance work was often coupled with a tape that was dragged along making no effort to correct for slope and such. I suppose many of the original surveyors did not concern themselves with slope corrections either. It is through this effort that original corner monuments were found along with old blazes and wire remnants on the ground and in trees. Resting stones for split rail fences could often be found by the diligent surveyor. These objects and discoveries were all marked for inclusion in the traverse that followed the reconnaissance.

The compass I used was mounted on a wooden pole known as a Jacob's staff. The end of the pole was metal. This end was pushed into the ground. The vanes or pointing columns of the compass were raised to reveal the face of the compass. The top of the Jacob's staff was swayed until the bubbles on the compass indicated the compass was level. At this point the needle was released to float and point toward the magnetic north or the machete, tape, pocket pen, or other metal held too close to the compass needle as so often occurred.

Speaking of local attractions to the compass needle, I will state that more than a few times, I used the compass to locate a buried pin under the ground by slowly moving the compass across the ground surface and looking for a twitch in the compass needle. I will remind my younger colleagues that metal detectors were not available when I first began practicing surveying. I will elucidate in some later article on the dip needle that preceded the metal detector.

Having released the compass needle from its mechanical constraints, the surveyor would wait for the needle to settle down. The compass needle was a contrary pointer much like a five year old with too much energy. I often voiced my thoughts to the needle in order to hurry the needle toward a decision. The needle always ignored my advice.

Once the needle decided to rest without skittering, the compass could then be rotated to read the bearing that was desired. At some point during a survey-apprentice's first acquaintance with a surveyor's compass the user realizes that east and west are reversed on the face of the compass - the east mark being to the left of north and west being to the right of north. This is not a design flaw. This allows the compass reading to be made directly off the pointing of the compass. I suppose I can try to explain how this works but I believe an explanation would be better understood if left to the person that is at the historical survey equipment display to explain this layout by actually showing the results using an actual compass.

The direction was then set on the compass. The vanes of the compass were sighted through in order to spy some object to align with and the measurements made with the tape to reach the object selected. Once the far object was reached, the compass was uprooted from the ground and the surveyor headed for the object to repeat the process. Woe be to the compass operator who did not collapse the vanes and did not fasten down the needle or brake the needle before uprooting the compass. Failure to fasten the needle would cause the pivot or spindle to be bent and the compass to err in its next pointing or perhaps not to point at all.

It is my experience and observation to state that the very best compass could measure the arc to the nearest quarter of a degree. The compass I used for reconnaissance would measure to the nearest degree. I will speak no more on the vagrancies of the compass and the magnetic needle since those probably deserve their own article. It is worth mentioning that many compasses had a personality of their own such that two compasses placed over the same point and pointed toward the same object could vary in their direction by as much as a degree or so. In early texts explaining the subject of surveying with the compass, the surveyor was cautioned to know the temperament of their compass. Many states had laws requiring the surveyor to set their compass over a designated stone and point to another stone in order to check the peculiarity of their compass.

Switching to the transit, I must first introduce the tripod the transit set upon. It was wooden, made from heavy wood such as oak. The legs of the transit tripod could not be adjusted in length. It was using great skill that a transit was placed over a point upon a hillside and still be leveled. The fastening ring for the transit upon the tripod was large and often as not gave me some difficulty in getting the threads to start. My difficulty oftentimes being caused by the small chain and hook that hung from the bottom of the transit upon which the plumb bob was hung. It seems this chain was always in the way of the thread when first placing the transit upon the tripod.

Without adjustable legs, a good deal of pushing and prodding of the legs into the ground took place in order to position the suspended plumb bob over the point. Having been a Marine, a few cuss words were used as well to gain some cooperation from the tripod legs. Numerous minutes of time were lost during the work day on this endeavor. A little grace was provided in this procedure by loosening one leveling screw in each of the two directions thereby allowing the transit to be shifted around an inch or so without wrestling with the tripod.

Having positioned the transit over the point, the next task was to level the transit. Some of the last transits commercially produced had three leveling screws but the ones I used had four leveling screws. Great care had to be exerted to balance opposing screws during the process of leveling the transit. Failure to exert the care required would leave one screw too loose resulting in the instrument wobbling along the axis. Too tight and there was a torque introduced or the brass threads were stripped. As I was often told, the screws had to be snug when the leveling process was complete. The transits I used had two plate bubbles, their axis perpendicular to the other, revealing the level of the transit in perpendicular directions.

Once the transit was leveled, the instrument plates had to be set to zero. This involved releasing the upper and lower motions of the transit and spinning the plate around using the fingers until a zero was approximately reached on the plates. The upper motion was then locked and the upper slow motion used to set the zero to a tolerance possible with the instrument. The lower motion remained loose until the instrument was sighted on the backsight target. The lower motion was used to put the cross-hairs on the target since the lower motion did not affect the reading on the plates.

In mentioning the upper and lower motions, I have introduced a common mechanism that has disappeared from the modern instrument that I do not wish to explore to a great

extent. Both the upper motion and lower motion had a release knob and a slow motion knob. Both knobs control the horizontal rotation of the transit. The lower knobs would do so without changing the reading on the plates. The upper knobs would change the reading of the plates. The lower knobs were used to point to a target without changing the angle reading. No one who used the transit can say they did not use the wrong knob from time to time. The problem arises because the person is looking through the optics while wishing to move the cross-hairs on to the target. Their hands grasp for a knob while they look through the scope. Of course either slow-motion knob will move the scope. The mistake is realized when they have aligned the cross-hairs on the target and look at the plates. The mistake is usually discovered at this time and some cuss words often escaped from the lips. This mistake always seemed to occur when attempting to double the angle, requiring the instrument operator to begin the tedious process of measuring the angle all over again.

The angle on the transit was read using one of two windows found around the ring of the transit. One was known as the A Vernier and the second known as the B Vernier. The windows were 180 degrees opposite or should be if the instrument was in good temper - the letters A or B being found in the window at the Vernier scale. Looking into the window, two rings of etched lines and numbers could be viewed. There was an inner ring and outer ring. The outer ring was the Vernier.

I will avoid attempting to describe the process of reading the transit plates and Vernier. I do not believe I could do the process any justice unless the reader was looking in the window of the transit while an explanation is made. The process involved remembering in which direction the instrument is rotated and finding where a line on the inner plate coincides with a line on the outer plate. Lines and spaces are counted. The reading from the inner plate is added to the outer plate to arrive at an angle. The lines and spaces had different values depending on the 'least count' of the instrument.

If a surveyor spent their entire career reading the transit, I expect one eye would be bigger than the other eye given the strain on the eye spent finding a coincident line between the primary and Vernier plates. Even in my younger days when my eyes were in the peak of fitness, I often employed the magnifying glass that was tied by a string to the transit standard.

One employer was very proud of the fact his transit could read to the nearest 15 seconds. I think it is easier to follow a spider's tracks than determine which of the numerous lines on a 15 second transit coincides. Needless to say the effort spent obtaining an angle took considerably more time than current practice with modern instruments.

Many modern instruments will not give a reading if the instrument is not leveled. I can say without hesitation, from numerous testings that I have partaken, that there was no impediment in reading a transit that was not level. I will not admit to making that mistake but I have observed numerous instrument persons do so.

I should also mention that the transits I used had a compass within the center of the transit that could be very helpful when retracing old boundaries or giving a magnetic direction to start a traverse.

I will close my reminisce about the transit by saying it also had a direct and Vernier plate allowing the instrument to read a vertical angle. For the surveyor that wished to use their

transit as a level, there was a large plate level parallel with the scope. Once this was leveled, the scope was level, assuming there was no instrument deficiency.

I wish to point out that contrary to measuring a zenith angle, the vertical angle required the instrument operator to include a plus or minus sign to be associated with the angle. The plus or minus sign would indicate if the scope was pointing up (+) or down (-) from the horizontal when the vertical angle was read.

I remember expressing my surprise to a survey crew chief after he returned from a topographic survey. My surprise came about when I presumed that he had managed to find the lowest spot to set up the instrument on that particular day since every vertical angle that was recorded in the field book was positive. Unfortunately, the instrument was not at the lowest spot. It was a day wasted since his memory was not sufficient to differentiate the negative angles from the entire list of positive angles that were recorded in the field book.

I will close this reminisce without delving into procedures that were employed to double the angle that should have been done but was often omitted in an effort to hurry the completion of the survey.