The Tellurometer as Used for Highway Control Surveys in Virginia

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This paper contains the operational procedure of the Tellurometer in Virginia for Highway Location and Ground Control Surveys, and a discussion of the results obtained through use of the Tellurometer under varying topographic and atmospheric conditions.

●THE VIRGINIA Department of Highways first became interested in the Tellurometer in the fall of 1957 and immediately began to investigate the possibility of using this instrument for the ground control surveys in the photogrammetric section which was being organized at that time. It was apparent from the beginning that this instrument would add flexibility to surveying which would combine the best features of traversing with those of triangulation. As in traversing, the strength of figure would not be very important; and as in triangulation, the character of the terrain between stations would be of very little importance so long as the stations were intervisible. The Department has used the Tellurometer since August 1, 1958, for ground control surveys and for some of the interstate location surveys.

When the Department first acquired the Tellurometer, one master and two remote units were purchased which were loaned to the USC&GS for establishing horizontal control points at intervals of 3 to 4 mi along the interstate highway routes in Virginia. During this time, the Tellurometer was borrowed from the Coast Survey for a few days at a time and measured the more difficult courses on the ground control traverses. At times an entire traverse would be measured where the terrain was unfavorable for traversing by conventional methods. It later developed that the Coast Survey was using only one remote unit due to a shortage of personnel. Another master unit was purchased and this system was turned over to the ground control survey parties. The Coast Survey completed the horizontal control along Virgina's interstate routes in July 1959; and since that time, two Tellurometer systems have been used on a full time basis.

To date, meteorological conditions have had very little effect upon the accuracy of the work. Lines were remeasured which were suspected of containing an error using the Tellurometer, and the results have agreed with the initial reading although several weeks may have elapsed between the time the two readings were taken. These lines would later be taped and found to contain an error of from 1.0 to 1.6 ft. The greatest errors are generally in short lines of less than 1,500 ft and over highly reflective surfaces or where the ground clearance was only a few feet throughout the line. In most cases, the tape-measured distance has been less than the Tellurometer distance. This would indicate that reflections were causing some of the trouble. The instruments are not equipped with crystal ovens. This has caused some trouble in synchronizing the crystals in cold and in hot weather; however, it is felt that this does not affect the accuracy of the work. Some of the best closures have been obtained in cold weather when it was necessary to warm the remote unit, by keeping it in a vehicle until ready to measure, in order to synchronize the crystals.

The Department tried to use the Tellurometer to obtain the secondary control for the 50 ft to 1 in. scale topographic mapping in urban areas, and this is where the greatest difficulty was had. These lines were short and over highly reflective surfaces. It was found by taping these lines that over 90 percent of the Tellurometer measured distances agreed with the taped distances; however, there was no way of predicting which of the Tellurometer measured distances would contain an error. This traverse was originally set up as a Tellurometer traverse due to the heavy traffic in this urban area, which was running both parallel and normal to the traverse lines being measured. The interference from traffic in this urban area was less than expected, and the break was relatively still and could be read very fast during those brief periods when the line was not actually blocked.

The Tellurometer was previously used in rural areas on much longer lines which were parallel to the road, and traffic had slowed down the reading due to the fact that it would cause multiple circles; and the break in the circle would be very unsteady. It seems that this interference in caused by reflections from vegetation along the road which is disturbed by the air currents from the passing vehicle as the multiple circles continue after the vehicle has passed.

Recently the Department has been traversing between the P.I.'s on the interstate location surveys. First, the survey party hubs the line through and establishes the P.I.'s. Then the Tellurometer party traverses between P.I.'s along the most convenient route. This survey is tied into the U.S. Coast and Geodetic Survey's horizontal control stations and adjusted. The adjusted position is then held to as the correct position and is used throughout the survey. The survey information P.I.'s, P.C.'s, P.T.'s, etc. is then calculated; and several survey parties may start work on establishing the actual survey centerline on the ground from several places along the line at the same time. The survey party running in the centerline is expected to check the calculated length. Using this approach on a project 23 mi in length, one of the distances between P.I.'s was found to be short by 1.7 ft. This tangent, 6,500 ft in length, was measured in two courses along the centerline; one course of 2,300 ft and the other 4,200 ft; and the measurements had been made on two different days. The traverse closure was 1:39,000; and the adjustment had shortened this course by 0.2 of a foot, while the actual distance was found to be 1.49 ft longer than the original measurement. This line was twice checked by horizontal taping along the centerline, once by remeasuring the Tellurometer measured distance using the original traverse points and twice by measuring the Tellurometer measured distances using different or new traverse points. These distance measurements along a different route were made on different days; once when there was about an inch of snow on the ground and later after it had melted. There were five check measurements along this line, and the maximum spread was 0.3 ft. The error in the first course of this line was 1:4,591; and 1:4,309 in the second course. For the original length by the Tellurometer to check, the refractived index would have to be 0.064 per thousand feet. In Virginia, the refractived index is normally between 0.27 and 0.33 ft per thousand feet. This traverse was in what is considered to be Tellurometer country—rolling pasture land with very few trees, where the line of sight was from 100 to 150 ft above the ground in the high places. This is the only line ever remeasured where the Tellurometer failed to check its original measurement within 0.3 of a foot. In fact, on a later traverse in the same area where a mistake was made in computing the closures and six courses were reread, the difference in distances varied only from 0.01 to 0.1 of a foot.

In the normal traverse work with the Tellurometer where it is necessary, due to wooded areas, to traverse along a heavily traveled road, it is not always apparent that the Tellurometer is affecting an increase in efficiency, for it sometimes takes longer to measure some courses with the Tellurometer than by chaining. However, at the end of the traverse it is realized that good progress has been made since the number of angle points has been reduced by as much as 50 percent; and this means not only the time saved in not having to occupy these points but also the time saved by not having to reference and describe them. It was also found that fewer men have been required because there were no flagmen used nor was the flow of traffic interrupted, and the men have worked from a much safer and more comfortable position.

In traversing in areas where it is possible and convenient to get away from the road, the Tellurometer is good from the standpoint of public relations, as it does not leave any tracks or tear down any fences; and most of the property owners are unaware that a survey party is working in the area.

The instrument, as now constructed, was intended primarily for geodetic surveying with long lines and few setups, rather than the relatively short lines which are normally employed; and although the design is excellent for an instrument that is only one model away from the prototype, the design could be improved to make it more convenient for the Department's purposes. It is believed that the barometer and psychrometer should be built into the Tellurometer case and the Tellurometer circuit should be built around the reflector as some television sets are built around the cathode ray tube so that it would not be necessary to put this reflector up every time a new station is occupied. The Department expects to measure 12 courses a day, and any saving in setup time is important. The transistorized power pack is a step in this direction.

Some simple method of elevating the antenna at least 5 ft above the present instrument for use in traffic is desirable. This would probably also increase the accuracy of the instrument on short lines with low ground clearance. Also, it would be desirable to have a swivel-type mount on the instrument so that it could be pointed and leveled more readily.

It was found that it is easy to train good Tellurometer operators from among the youngest men on the survey parties, as these men are anxious to learn to use the instrument. In fact, the Tellurometer has been well accepted by all survey party personnel, and they use the instrument at every opportunity.

On some projects, the Tellurometer has reduced the cost of horizontal control by 70 percent, if calculated on the basis of comparable accuracy by some other method of control.

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