USE OF THE GEODIMETER BY THE COAST AND GEODETIC SURVEY

by Paul D. THOMAS
Mathematician, U.S. Coast and Geodetic Survey

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Abstract

The Coast and Geodetic Survey has measured 84 geodetic lines with the Geodimeters, Models 1 and 2, over a five-year period. Based on this experience, a routine of field operations has been developed and a manual of operation is being prepared. Maintenance problems have been negligible and only minor modifications of the instruments have been made. The Coast and Geodetic Survey recommends the Geodimeters (Model 1 or 2) for measuring first-order triangulation baselines, trilateration, traverse, and for calibrating electronic distance-measuring equipment such as the Tellurometer.

The Coast and Geodetic Survey obtained a Model 1 Geodimeter in 1953 and a Model 2 in 1956. The Model 2 is now used almost exclusively in the field for baseline measurement, the Model 1 serving as an emergency replacement instrument.

Through 1958, 84 lines had been measured with these instruments over various types of topography, such as water expanse, mountains, desert, rolling hills, and flat cultivated areas. The average line length was 16 480 metres (about 10 miles). The maximum and minimum lengths were 42 036 metres (26 miles) and 1 114 metres (0.7 mile). The minimum probable error of a result for all 84 lines was 0.8 mm; maximum 9.9 mm.

Field operations

Based on this experience, the Coast and Geodetic Survey has adopted a standard of 12 measurements, taking 6 measurements on each of two nights, as sufficient to give a first-order base length. One length determination is made by using four fine-delay readings on the light conductors (one in each phase position), four-fine delay readings on the retrodirective prism-bank reflector, and then four fine-delay readings on the light conductors. Relative humidity is determined at the beginning and end of a night's work. The mean of temperature and pressure readings taken at each end of the line are used with the mean relative humidity to determine the refraction correction.

A set of six measurements should be made in 75 to 90 minutes. A trained operator can work at that speed and better results will be obtained than when observations are made over a long period of time. Experiments indicate that if the instrument is operated properly, there should be no personal error in the observations.

The Geodimeters were found to be reasonably rugged, but vibration or rough handling would break electrical connections. A short connection on one of the fuse boxes broke repeatedly. The neon bulbs had to be replaced every two or three weeks. On one occasion a thermometer controlling a crystal oven froze. Photomultiplier tubes had to be replaced about six times over the period of operation (about 5 years). The small focusing mirrors in the Model 1 had to be replaced and the large mirrors in both models have to be resilvered once a year (standard procedure). The Model 1, while being used in extremely hot weather, developed an oil leak in the null indicator instrument. The saturable reaction of the primary power circuit in the Model 1 had to be adjusted on several occasions. In both models some of the capacitors in the fine-delay circuit had to be replaced with negative coefficient capacitors to eliminate drift in the fine-delay circuit. One of the frequency crystals in the Model 2 had to be replaced. On only one occasion (photomultiplier-tube malfunction) was it necessary to bring an instrument into the shop. All other repairs were made in the field. The maintenance required was considered normal for this type of equipment.

In operation, one end of a line should be a drive-on station, or the instrument transported by helicopter, since its weight and auxiliary equipment (electric generator, etc.) makes backpacking impossible.

The Geodimeter has been used successfully on 12-foot wooden towers, but attempts to use it on a 103-foot Bilby steel tower were unsatisfactory. The observer's platform is not designed for so large an instrument; a boom is required on the tower to swing the instrument into position. Vibration in the tower makes it extremely difficult if not impossible to null the instrument. However, the retrodirective prism-bank reflector may be used from the Bilby tower and vibrations even in wind will not prevent observations.

Modifications

The Coast and Geodetic Survey has made the following modifications in its Geodimeters :

Holes were drilled through the back of the lamp assembly so that the adjustment screws on the lamp would be accessible without disassembling the instrument.

Insulated jacks were installed so that the bias voltage on the photomultiplier tube could be read without removing the bottom plate of the Geodimeter case. (Excessive bias voltage indicates a needed change of neon bulbs).

A removable plug was installed in the side of the photomultiplier case allowing adjustment of the RF voltage in the photomultiplier circuit without disassembly.

Extra desiccating material (silicagel) was added to the light-conductor box and to the phototube unit to prevent moisture from affecting the crystals and the high-impedance circuits.

Some results and future use

Four first-order taped bases were measured and checks of 1/508 000, 1/535 000, 1/158 000, and 1/177 000 were obtained. These comparisons contain the errors in taping as well as the Geodimeter errors. On three occasions (each in a separate quadrilateral) a line was measured in a quadrilateral in which one line had been taped. These comparisons were 1/160 000, 1/1 470 000, and 1/143 000. Most of the 84 lines measured with the Geodimeter were used directly in triangulation adjustments and have proved satisfactory as first-order bases. The Geodimeter has also been used occasionally to check adjusted triangulation lines to determine if any distortion has been introduced by the adjustment.

Because of the material savings over standard taping procedures and the ability to insert baselines where taping would be practically impossible, and thus strengthen the net wherever needed, the Coast and Geodetic Survey is using the Geodimeter (Models 1 or 2) almost exclusively for baseline measurement. On short accessible lines, where a high degree of accuracy is required, the standard invar-tape measuring technique will of course be used, but this is not a frequent requirement. The Geodimeter is also being used in the Bureau's long-range program for measuring lines in older surveys so that when the triangulation of the United States is readjusted (in about 20 years) better length control will have been established.

More recently plans have been completed for establishing a super-triangulation net in California to study earth movements. It is to be saturated with Geodimeter-measured lines (10 to 15 % of the lines) so that internal accuracy of 1/200 000 can be maintained through the net. This will permit resurveys in shorter time periods to detect earth movement.

A new manual of operation

The Coast and Geodetic Survey has under preparation a new manual on the operation of the Model 2 (or Model 1) Geodimeter based on its experience with the instrument and the recommendations of the manufacturer. The manual will include Geodimeter set-up and operational procedures; Computations (including computing forms and necessary tables); Troubleshooting in the field; Reconnaissance for Geodimeter baselines; Alignment of the electronic and optical systems; Calibration, and Analysis of error sources. It should be available from the U. S. Government Printing Office in July or August of this year.

Summary recommendations

Since the Geodimeter Model 2 (or Model 1) is capable of consistently measuring lengths up to about 30 miles with a proportional-part accuracy of 1/200 000 or better, it is recommended for first-order triangulation baseline measurements with 20-mile lines considered an optimum maximum and 10-mile lines an optimum minimum. The instrument can be used for trilateration or traverse but transporting the equipment becomes a real problem, particularly in rough terrain. It may be used to calibrate other distance-measuring instruments such as the Tellurometer.