COOKE, TROUGHTON & SIMMS, Ltd.
YORK, ENGLAND

During the course of the Sixth International Hydrographic Conference, films concerning the use of the following instruments were shown by this firm:

The Surveyor's Level: This film dealt with the Cooke S 300 Level. The accuracy of this apparatus depends on the resolving power of the telescope and the smallness of the angle which the spirit level will register. When sighting through such a telescope, the eye is able to resolve points subtending angles of sixty seconds divided by the magnification of twenty times or three seconds of arc.

The focussing is done by means of a ring without changing the length of the telescope. The vial which constitues the spirit level has a radius of about 20 metres which gives a 2 mm. movement to the bubble when tilted through twenty seconds of arc. Mounted above the spirit level is an optical device which allows for accurate setting of the level and brings the images of the two ends of the air space into coincidence. The level is set by means of a differential screw thread, one complete revolution of which is equal to about one-five-hundredth of an inch in a vertical direction.

The Geodetic Level: This Level, which is in tended for making level traverses over comparatively long distances, has the highest degree of accuracy; in particular, mention should be made of a spirit level vial, ground internally in such a manner that, when rotated about its axis of symmetry — with that axis truly horizontal — or about a telescope axis parallel to it, the bubble will remain centred about the section of greatest internal diameter of the vial and the line of sight of the telescope will then indicate the same staff reading whatever the radial position of the telescope.

This device enables the true level to be found by taking the average of two staff readings arrived at by rotating the telescope 180° about its optical axis.

The perfect centring of the bubble in the vial is obtained by means of a system of readings on two central lines across a prismatic system which brings the images at the two ends of the bubble into the line of vision.

For geodetic levelling, a special precision staff is used upon which are mounted graduated « Nilex » steel strips anchored at one end only and having a negligible coefficient of expansion.

To obviate the needs of estimating between the telescope cross line and the nearest staff graduation, this geodetic level is fitted with a parallel plate micrometer. When this parallel glass plate is in a vertical position, the rays from the staff are unaffected by it; if it is inclined, a parallel displacement of the line of sight is produced, thus bringing the nearest staff division on to the telescope cross line; the required reading is then the sum or the difference of the staff and micrometer readings. This displacement is read, to one-thousandth part of a foot, on a micrometer control drum at the eye-end of the instrument.

Base Line Measurement with « Macca » Equipment: In the triangulation measurements taken with geodetic theodolites, the readings of these apparatus are made directly to 0.5 second of arc. This is very nearly equivalent to the angle

subtended by the diameter of a half penny at 6 miles; i.e., it gives a precision of about 1/500 000.

To measure a base, use is made of calibrated Invar tapes suspended between two points under a known load. The set of apparatus used was designed under the direction of Captain McCaw (who was widely known for work of the highest order) and came to be known as « Macca » equipment. Any distance can be covered by the repeated use of these tapes together with two straining trestles and a number of intermediary measuring heads. These heads are placed in position along the projected base line and it is between them that precise distances are measured. When in use, the measuring tape rests upon the central spigot against the engraved fiducial line and the graduations on the tape are read off against this line by the aid of a hinged magnifier. The head is levelled with three screws against two spirit levels, and, without disturbing this setting, the spigot can be adjusted laterally and rotated as necessary to line it up with the tape. A telescope fitted on top of the magnifier mount is used for the alignment of the different measuring heads and for determining the slope of each bay to a maximum depression of 10°. Sighting vanes facilitate the alignment and are interchangeable with the aligning telescope, the centre of the cross wires being at the same height as the transit axis of the telescope. These sighting vanes are illuminated, as it is sometimes preferable to work at night.

The Invar tape is suspended between two straining trestles over self-aligning pulleys and is subjected to a known tension by means of applied weights. The pulleys can be adjusted both vertically and horizontally to enable the tape to be correctly positioned on the measuring heads. The Invar measuring tapes are calibrated by the National Physical Laboratory to one part in a millionth of their length whilst under a tension of 20 lbs. Both ends of the tape are graduated over 100 millimetres, the precise positioning of the measuring heads relative to the tape thus becoming unimportant. Some of the measuring heads contain an optical plummet for transferring the fiducial mark to the ground when necessary.

Each section of the completed base line is remeasured in the reverse direction to eliminate systematic errors of direction and as a check on the first results. To obtain the final value of the base length in each direction, a series of corrections, including those for temperature and slope, must be applied for each bay. Corrections for variation in gravity and standard lengths of the tapes are applied to the whole base. The weighted mean of these two measurements is then referred to mean sea level, which is the common basis to which the whole triangulation is reduced, and an estimate is made of the probable errors affecting the final result by comparison of the two measures for each section.

Naturally, in the case of an extensive triangulation, it is necessary to measure from time to time other bases at some distance from the original base to provide a scale to which the intervening triangulation must be finally adjusted.

In the recent re-triangulation of Great Britain, the probable error of the base lengths measured with this apparatus was one part in 987,000. The reproduction of one base carried forward through 440 miles of triangulation to the other base agreed with direct measurement to one part in 97,000.

These figures clearly indicate the high degree of human and instrumental precision which must be exercised throughout such a primary survey.