

scale to the left of zero, then the full reading will be, say, 60·2855, the 5 in the fourth place being read by estimation on the sliding steel scale, and a strong magnifying glass being always used. If the link-mark is on the scale, but to the right of the zero, then the reading will be, say, 59·7145, the parts of the link in this case being read from the right end of the scale, the 59-link mark being then the first to the left. If the tape comes from the right, the method of reading is relatively the same, and, though the scale-figures will be upside down, there will be no difficulty in reading them.

All the tapes are graduated by fine engraved lines drawn right across on the material of the tape itself. As, however, these lines are frequently not precisely at right angles to the length of the tapes, it follows that the graduations on the one edge are not in accord with those on the other; but each edge presents the features of a separate tape, and was treated as such, and standardized accordingly. At each end of the tapes 1 chain-length is graduated to links. The tapes are numbered 01, 02, and 03, the ends are marked A and B, and the two edges of each tape are also distinguished by the letters A and B, all engraved on brass sleeves soldered to the tapes. In using the tapes, of course, the great number of the measurements are of approximate 5-chain lengths, sometimes a little more, sometimes a little less, but whether greater or lesser, the small excess or deficiency from the full chain was measured altogether on the scale attached to the theodolite. Owing to obstacles, however, there are a few irregular lengths on sections 3 to 8, and on section 9 the greater part of the measurements are irregular. To minimize errors in the odd link-values, each link was separately tested on a link-comparator, laid down from an Invar standard link-bar specially supplied by W. F. Stanley, London, and a schedule of the plus and minus link-values made. Subsequently the two half-chain lengths of each graduated link-tape were tested against one another, and their values obtained in terms of the value of the whole chain-length in each case. These were compared with the sums of the plus and minus link corrections in the schedule, which latter were then adjusted in accordance therewith. The corrections to the direct comparison-values in the schedules never exceeded 2 in the fourth place of decimals of a link, and frequently were less than 1.

For comparison of links and adjustment of values see Table No. 2.

Fourth: Three measuring-tripods. These are made of galvanized-iron tubing $\frac{3}{4}$ in. in diameter, with sliding adjustment gun-metal tops, with a further fine centring movement, obtained by two pairs of opposing screws. (See Fig. No. 7.)

Fifth: Measuring-stand. The measuring-stand consists practically of a $\frac{3}{4}$ in. steel shaft rising from a weighted iron frame, and carrying a slow-motion screw for making the contacts of rear end of tapes with the engraved initial-mark on the gun-metal tops of tripods. The frame of the slow-motion screw has a sliding movement up or down the shaft, and also separate horizontal and inclination movements, so that when all are brought into service the contacts can be made readily and with precision for the usual heights of tripods (about 3 ft. 6 in.), and on any grade. (See Fig. No. 8 for details, and No. 9 for stand in use.)

Sixth: Straining-apparatus. Referring to Fig. No. 10: One end of the tension-wire D is first hooked on to the frame of the pulley attached to the stayed shaft, which is always placed on the line being measured. The other end of the wire is then passed under the upper pulley on the galvanized-iron rod A, which pulley is also placed on the line to be measured, then over the pulley, and carried down above the first part of the wire to the ground pulley again, which it passes over and under, to be clamped to the slow-motion screw in the tension-frame E run down near to the ground-level. The balance K is attached to a rider which circulates round the axis of the upper pulley, just clearing its rim. When the balance is therefore clamped to a tape, say, roughly, in a horizontal position, the other end of the tape being rigidly fixed to the measuring-stand, a position of mechanical equilibrium and low tension is set up in the tape and tension-gear. This tension is rapidly increased by raising the tension-frame, which slides on the galvanized rod A, the action naturally being to lengthen the distance between the low pulley and the tension-frame, which can only be accomplished under the circumstances by a corresponding shortening of the distance between the upper and lower pulleys. As the low pulley cannot move, the upper one must; the result being, as it is pulled back, strain is applied to the balance, and the required tension obtained, first rapidly by the sliding movement of the frame upwards, and then accurately by the slow-motion screw.

Seventh: Spring balance. A Salter's spring balance of German silver, circular make, and about 3 in. long, was used for putting the required pull on tapes. This balance was compared at every test of the tapes on the comparator with a standard balance, by means of the known elastic extension of the tapes used in the work.

Eighth: Support-stands. These are made of cast iron, their essential workmanship consisting of a universal joint, to the upper surface of which a blue-gum rod 6 ft. to 7 ft. in length is attached. Sliding up and down on the rods are spring-steel supports with knife-edges, on which the tapes rest when in use. (See Fig. No. 11.)

Ranging.

The ranging of the line, and the insertion of the terminal and intermediate marks, were carried out by Mr. H. J. Lowe, a preliminary measurement being also made to break the line up as far as possible into 5-chain lengths. On section 9, however, this practice had to be departed from owing to the irregularities of the section and the necessity of closely following the grades of the country to avoid the action of the wind on the tapes.

Standard of Length.

The only standard of length for comparator purposes in the Dominion at present is the 100 Imperial links steel tape No. 1, in the Head Office of the Lands and Survey Department, Wellington. This tape, $\frac{1}{2}$ in. by $\frac{1}{50}$ in., was tested by the Standards Department of the Board of Trade, London, in 1903, and its value given under certificate, as being the true Imperial standard length of 100 links at 62° Fahr., and under a tension of 15 lb. The coefficient of expansion for temperature and the modulus of elasticity were not given. The temperature coefficient adopted is 0·0000625 per degree Fahr.