the astronomical and adopt the trigonometrical basis. In India the change was made in 1800, when what is known as the Great Trigonometrical Survey was initiated by Major Lambton—with the support of Colonel Wellesley, after­wards Duke of Wellington—as a means of connecting the several surveys of routes and districts which had already been made in various parts of the country, and as a basis for future topography. This necessitated the inception of the survey as an undertaking calculated to satisfy the re­quirements of geodesy as well as geography, because the latitudes and longitudes of the points of the triangulation had to be determined for future reference,—as in the case of the discarded astronomical stations, though in a different manner,—by processes of calculation combining the results of the triangulation with the elements of the earth’s figure. The latter were not then known with much accuracy, for so far geodetic operations had been mainly carried on in Europe, and additional operations nearer the equator were much wanted ; the survey was conducted with a view to supply this want. Thus a high order of accuracy was aimed at from the very first. In course of time the operations were extended over the entire length and breadth of Hin­dustan and beyond, to the farthest limits of British sway ; they cover a larger area than any other national survey as yet completed, and are very elaborate and precise. Thus, as triangulation constitutes the most appropriate basis for survey operations generally, a short account will be given of (1) the methods of the Great Trigonometrical Survey of India. This will be followed by accounts of (2) traversing as a basis for survey, (3) levelling, (4) survey of interior detail, (5) representation of ground, (6) geographical recon­naissance, (7) nautical surveying, (8) mapping, (9) map printing, (10) instruments.

I. Great Trigonometrical Survey of India.

1. *General Outlines.—*Primarily a network was thrown

over the southern peninsula. The triangles on the central meridian were measured with extra care and checked by base-lines at distances of about 2° apart in latitude in order to form a geodetic arc, with the addition of astronomi­cally determined latitudes at certain of the stations. The base-lines were measured with chains and the principal angles with a 3-foot theodolite, which, however, was badly damaged almost at the outset by an accident to the azimuthal circle. The signals were cairns of stones or poles. The chains were somewhat rude and their units of length

had not been determined originally, and could not be after­wards ascertained. The results were good of their kind and sufficient for geographical purposes ; but the central

meridional arc—the “great arc”—was eventually deemed inadequate for geodetic requirements. A superior instru­mental equipment was introduced, with an improved *modus operandi,* under the direction of Colonel Everest in 1832. The network system of triangulation was superseded by meridional and longitudinal chains taking the form of grid­irons, and resting on base-lines at the angles of the grid­irons, as represented in fig. 1. For convenience of reduc­tion and nomenclature the triangulation west of meridian 92° E. has been divided into five sections,—the lowest a trigon, the other four quadrilaterals distinguished by cardinal points which have reference to an observatory in Central India, the adopted origin of latitudes. In the north-east quadrilateral, which was first measured, the meridional chains are about one degree apart; this dis­tance was latterly much increased, and eventually certain chains—as on the Malabar coast and on meridian 84° in the south-east quadrilateral—were dispensed with, because good secondary triangulation for topography had been accomplished before they could be commenced.

2. *Modern Base-Lines.—*All these were measured with the Colby apparatus of compensation bars and microscopes. The bars, 10 feet long, were set up horizontally on tripod stands ; the microscopes, 6 inches apart, were mounted in pairs revolving round a vertical axis and were set up on tribrachs fitted to the ends of the bars. Six bars and five central and two end pairs of microscopes—the latter with their vertical axes perforated for a look-down telescope— constituted a complete apparatus, measuring 63 feet be­tween the ground pins or registers. For explanation of compensation see Earth, Figure of the, vol. vii. p. 599. Compound bars are necessarily more liable to accidental changes of length than simple bars ; they were therefore tested from time to time by comparison with a standard simple bar; the microscopes were also tested by comparison with a standard 6-inch scale. At the very first base-line the compensated bars were found to be liable to sensible variations of length with the diurnal variations of temper­ature ; these were supposed to be due, not to error in effecting the compensation, but to the different thermal conductivities of the brass and the iron components. It became necessary, therefore, to determine the mean daily length of the bars very precisely, for which reason they were systematically compared with the standard before and after, and sometimes at the middle of, the base-line measurement throughout the entire day for a space of three days, and under conditions as nearly similar as possible to those obtaining during the measurement. Eventually ther­mometers were applied experimentally to both components of a compound bar, when it was found that the diurnal variations in length were principally due to difference of position relatively to the sun, not to difference of con­ductivity,—the component nearest the sun acquiring heat most rapidly or parting with it most slowly, notwithstand­ing that both were in the same box, which was always kept under the cover of a tent and carefully sheltered from the sun’s rays. Happily the systematic comparisons of the compound bars with the standard were found to give a sufficiently exact determination of the mean daily length. An elaborate investigation of theoretical probable errors at the Cape Comorin base showed that, for any base­line measured as usual without thermometers in the com­pound bars, the *p.e*. may be taken as ± 1·5 millionth parts of the length, excluding unascertainable constant errors, and that on introducing thermometers into these bars the *p.e.* was diminished to ± 0·55 millionths.

In all base-line measurements the weak point is the determination of the temperature of the bars when that of the atmosphere is rapidly rising or falling ; the thermo­meters acquire and lose heat more rapidly than the bar if