of gradients ; and then the contour lines, and the orthogonals also if required, are laid down.

VI. Geographical Reconnaissance.

When a traveller passes through an unknown or little known region the opportunity afforded him of acquiring ' some new geographical knowledge depends largely on the configuration and aspects of the ground, the condition of the atmosphere, the attitude of the inhabitants, and the time available. If hills are numerous and prominent and free from forest, and other conditions are favourable, a large area may be covered in a short time by reconnaissance from the stations of a chain of triangles carried along the line of route, fixing points in advance, some of which be­come stations of observation whence further points are fixed ; and thus the continuity of the operations is main­tained. But the ground may be flat and devoid of pro­minent points, the view circumscribed by forests and other obstacles, the atmosphere dense and unfavourable for distant vision, the inhabitants hostile, and the time short, and the traveller may be restricted to his line of route and unable to deviate from it ; he must then endeavour to maintain a continuous traverse of the route, sketching in the ground in its immediate vicinity. Whenever breaks of continuity occur he must resort to astronomical observations to effect a connexion between the dissociated sections of his survey and to obtain an independent check on the general accuracy of the operations. He has therefore to be prepared to measure base-lines, to carry on a triangulation in some regions and a traverse in others, and to make any astro­nomical observations which may be wanted, and, if possible, to complete his mapping on the ground instead of post­poning it to be done elsewhere. He should supply himself with some instruments suited for rough and rapid work and with others for better work when time and opportunity permit, and he should be careful to arrange beforehand the general character of the proposed operations and the scales and projections to be adopted for the mapping ; he should also provide himself with blank sheets of paper duly graticulated to scale, for work in detail in the vicinity of the line of route and for general geography. For measures of base-lines and distances on the ground, chains, rolls of crinoline wire, long Assam canes, and perambulators may be employed, also omnimeters and subtense theodolites, to measure the angle subtended by a pole of known length, whence the distance may be deduced. For measures of angles and bearings, either theodolites,@@1 or sextants, or prismatic compasses may be used, according as more or less accuracy is required. For the general survey the plane table is a most valuable instrument : it enables bearings to be at once laid down on the paper without previous measurement, and much detail to be sketched in on the spot, instead of being plotted subsequently from a field-book ; then the only independent angular measurements which need be taken are those of the principal triangles and of very distant points beyond the range of the table. Rough and rapid route surveys may be made by pacing the dis­tances, taking the magnetic bearings, and combining with the results of astronomical observation. Many thousand

miles of itinerary through regions in Central Asia have been surveyed by Asiatic employés of the Indian Govern­ment in this way ; the northings and southings were con­trolled by latitude observations, and the factors thus ob­tained were applied to the eastings and westings, longitudes being impracticable. The theodolite should be employed to fix points on very distant ranges, for it will give good results, even with short bases and very acute angles, pro­vided the objects actually observed are well identified in each instance. Observations should be taken from three stations, giving two triangles with a common side, which will at once show up any mistake, whether of identity, circle reading, or calculation. Whenever a break of continuity occurs in the triangulation or the traversing, astronomical observations must be resorted to. Much may be done by a judicious introduction of latitudes and azimuths, more par­ticularly where there is considerable northing and southing, for then differences of longitude may be obtained from the azimuths and differences of latitude. A prominent peak, visible from great distances all round, may be made to serve as a connecting link between regions which cannot be con­tinuously connected, by measuring its azimuth and distance from a base-line in each region ; the addition of latitudes at the azimuth stations will much strengthen the work.

*Collateral Astronomical Determinations. —* Determina­tions of azimuth, latitude, time, and longitude may all be required for geographical reconnaissance,—the first two more particularly, as they can be obtained readily with much accuracy ; the fourth, being much the most trouble­some to get and the least reliable when got, is only re sorted to when it cannot be dispensed with.

The azimuth of an object may be determined without calculation by observing the angles between the object and a star at equal altitudes on opposite sides of the meridian ; but it is generally found by observing the angle in one position of the star and applying thereto the azimuth of the star as obtained by calculation. In the spherical triangle *PZS,* in which *P* repre­sents the pole, *Z* the zenith, and *S* the star, the angle *PZS* is the star’s azimuth, which can be computed when any three parts of the triangle are given. *PS,* the polar distance of the star, is given by the tables, and *PZ,* the co-latitude, must be previously determined ; then, for the third part, we may have either (1) *PSZ,* a right angle, by observing a circumpolar star at its maximum elongation, or (2) the hour angle *P* for any star, by taking the time of the observation, or (3) the zenith distance *ZS,* by measurement simultaneously with the hori­zontal angle. Of these three methods the first is the most accurate, but it is not always convenient ; the second re­quires, in addition, special observations for time; the third is generally the most convenient, for it may be performed between sunset and dark, when the stars are coming into view, but when there is still sufficient light to illuminate the wires of the telescope and the referring mark, and thus enable lamps to be dispensed with.

The latitude is most readily determined by measures of stars’ zenith distances on the meridian, duly corrected for refraction ; then, the polar distance being known, the lati­tude is at once ascertained. The stars should be observed in pairs of nearly equal zenith distance, north and south, for this eliminates all constant instrumental errors, as of index, excentricity, and graduation, and also errors in the adopted refractions. When a single star is employed, circum-meridian observations of zenith distance may be taken and reduced to the meridian by calculation ; tables for the pole star are given in the *Nautical Almanac,* which enable an observation, taken at any known time in the 24 hours, to be reduced to the pole.

@@@1 In many respects a theodolite is more suitable than a sextant : (1) it measures horizontal angles directly, whereas the sextant measures oblique angles, which have to be reduced to the horizon ; (2) it mea­sures a round of several angles with much greater facility ; (3) it measures all vertical angles with equal facility, including the small elevations and depressions of distant peaks which cannot be readily seen by reflexion from mercury for measurement with a sextant ; **(4)** its telescopic power is usually far higher ; (5) it may be so mani­pulated as to eliminate the effects, without ascertaining the magni­tudes, of the constant instrumental errors,—excentricity, index, and collimation ; and (6) when much accuracy is required the influence of graduation errors may be greatly reduced by systematic changes of the settings of the horizontal circle.