of the final topography are drawn. The principal trigonometrical points are plotted on both these boards by their co-ordinates, and the camera stations either by their co-ordinate values or by intersection. Intermediate points, selected as appearing on two or more negatives, are then projected by intersection. The hori­zontal projection of a panorama consisting of any given numlær of plates is a regular geometrical figure of as many sides as there are plates, enclosing an inscribed circle whose radius is the focal length of the camera. Having correctly plotted the position of one plate, or view, with reference to the projected camera station by means of the angle observed to some known point within it, it is possible to plot the position of the rest of the series, with reference to the camera station and the orienting triangulation point, by the angular differences which arc dependent on the number of photographs forming the sides of the geometrical figure. Having secured the correct orientation of the horizontal plan, direction lines are drawn from the plotted camera station to points photographed, and the position of topographical features is fixed by intersection from two or more camera stations.

The plane-table is the instrument, *par excellence,* on which the geographical surveyor must depend for the final mapping of the physical features of the country under survey. The methods of adapting the plane-table to geographical requirements differ with those varying climatic con­ditions which affect its construction. In the comparatively dry climate of Asiatic Russia or of the United States, where errors arising from the unequal expansion of the plane-table board arc insignificant, the plane-table is largely made use of as a triangulat­ing instrument, and is fitted with slow-motion screws and with other appliances for increasing the certainty and the accuracy of observations. Such an adaptation of the plane-table is found to be impossible in India, where the great alternations of tempera­ture, no less than of atmospheric humidity, tend to vitiate the ac­curacy of the projections on the surface of the board by the unequal effects of expansion in the material of which it is composed. The Indian plane-table is of the simplest possible construction, and it is never used in connexion with the stadia for ascertaining the distances of points and features of the ground (as is the case in America); and in place of the complicated American alidade, with its telescope and vertical arc, a simple sight rule is used, and a chirometer for the measurement of vertical angles. The Indian plane-table approximates closely in general construction to the “ Gannet" pattern of America, which is specially constructed for exploratory surveys.

The scale on which geographical surveys are conducted is neces­sarily small. It may be reckoned at from 1 : 500000 to 1 : 125000, or from 1 in. = 8 m. to 1 in.=2 m. The 1 in. = 1 m. scale is the normal scale for rigorous topography, and although it is impossible to fix a definite line beyond which geo­graphical scales merge into topographical (for instance, the ι-in. scale is classed as geographical in America whenever the con­tinuous line contour system of ground representation gives place to hachuring), it is convenient to assume generally that geographical scales of mapping are smaller than the 1-in. scale.

On the smaller scales of 1 : 500000 or 1 :250000 an experienced geographical surveyor, in favourable country, will complete an area of mapping from day to day which will practically cover nearly all that falls within his range of vision; and he will, in the course of five or six months of continuous travelling (especially if provided with the necessary “ control ”) cover an area of geographical mapping illustrating all important topographical features representable on the small scale of his survey, which may be reckoned at tens of thousands of square miles. But inasmuch as everything depends upon his range of vision, and the constant occurrence of suitable features from which to extend it, there is obviously no guiding rule by which to reckon his probable out-turn.

The same uncertainty which exists about “ out-turn ” manifestly exists about “ cost.” The normal cost of the 1-in. rigorous topo­graphical survey in India, when carried over districts which present an average of hills, plains and forests, may be estimated as between 35 to 40 shillings a square mile. This compares favourably with the rates which obtain in America over districts which probably present far more facilities for survey­ing than India does, but where cheap native labour is unknown. The geographical surveyor is simply a topographer employed on a smaller scale survey. His equipment and staff are somewhat less, but, on the other hand, his travelling expenses are greater. It is found that, on the whole, a fair average for the cost of geo­graphical work may be struck by applying the square of the unit of scale as a factor to 1-in. survey rates; thus a quarter-inch scale survey (i.e. 4 m. to the in.), should be one-sixteenth of the cost per mile of the 1-in. survey over similar ground. A geographical recon­naissance on the scale of 1 : 500000 (8 m. = 1 in.) should be one-sixty­fourth of the square-mile cost of the 1-in. survey, &c. This is, indeed, a close approximation to the results obtained on the Indian transfrontier, and would probably be found to hold good for British colonial possessions.

In processes of map reproduction an invention for the reproduction of drawings by a method of direct printing on zinc without the intervention of a negative has proved of great value. By this method a considcrable quantity of work has been turned out in much less time and at a much lower cost than would be involved by any process of photo-zincography or lithography. A large number of cadastral maps have been reproduced at about one-ninth of the ordinary cadastral rate.

For the rapid reproduction of geographical maps in the field in order to meet the requirements of a general conducting a campaign, or of a political officer on a boundary’ mission, no better method has been evolved than the ferrotype process, by which blue prints can be secured in a few hours from a drawing of the original on tracing-cloth. The sensitized paper and printing-frame are far more portable than any photo-lithographic apparatus. Sketches illustrative of a field of action may be placed in the hands of the general commanding on the day following the action, if the weather conditions are favourable for their development. The necessity for darkness whilst dealing with the sensitized material is a draw­back, but it may usually be arranged with blankets and waterpr∞f sheets when a tent is not available.

5. Traversing and Fiscal, or Revenue, Surveys

Traversing is a combination of linear and angular measures in equal proportions; the surveyor proceeds from point to point, measuring the lines between them and at each point the angle between the back and forward lines; he runs his lines as much as possible over level and open ground, avoiding obstacles by work­ing round them. The system is well suited for laying down roads, boundary lines, and circuitous features of the ground, and is very generally resorted to for filling in the interior details of surveys based on triangulation. It has been largely employed in certain districts of British India, which had to be surveyed in a manner to satisfy fiscal as well as topographical requirements; for, the village being the administrative unit of the district, the boundary of every village had to be laid down, and this necessi­tated the survey of an enormous number of circuits. Moreover, the traverse system was better adapted for the country than a network of triangulation, as the ground was generally very flat and covered with trees, villages, and other obstacles to distant vision, and was also devoid of hills and other commanding points of view. The principal triangulation had been carried across it, but by chains executed with great difficulty and expense, and therefore at wide intervals apart, with the intention that the intermediate spaces should be provided with points as a basis for the general topography in some other way. A system of traverses was obviously the best that could be adopted under the circumstances, as it not only gave all the village boundaries, but was practically easier to execute than a network of minor triangulation.

In the Indian survey the traverses are executed in minor circuits following the periphery of each village and in major circuits comprising groups of several villages; the former are done with 4" to 6" theodolites and a single chain, the latter with 7*''* to 10*''* theodolites and a pair of chains, which are compared frequently with a standard. The main circuits are connected with every station of the principal triangulation within reach. The meridian of the origin is determined by astronomical obser­vations; the angle at the origin between the meridian and the next station is measured, and then at each of the successive stations the angle between the immediately preceding and follow­ing stations; summing these together, the “ inclinations ” of the lines between the stations to the meridian of the origin are succes­sively determined. The distances between the stations, multi­plied by the cosines and sines of the inclinations, give the distance of each station from the one preceding it, resolved in the direc­tions parallel and perpendicular respectively to the meridian of thc origin; and the algebraical sums of these quantities give the corresponding rectangular co-ordinates of the successive stations relatively to the origin and its meridian. The area included in any circuit is expressed by the formula

area=half algebraical sum of products (*x*1+*x*2) (*y*2-*y*1) (18), *x*1, *y*1 being the co-ordinates of the first, and *x*2, *y*2 those of the second station, of every line of the traverse in succession round the circuit.

Of geometrical tests there are two, both applicable at the close of a circuit: the first is angular, viz. the sum of all the interior angles of the described polygon should be equal to twice as many