points on the sides where they may be of use in the subsequent operations. The surveyor is given a diagram of the triangulation, but no side lengths, as the accuracy of his chaining is tested by comparison with the trigonometrical values. Then straight lines are carried across the intermediate detail between the points estab­lished on the sides; they constitute the principal “cutting up or split lines ” ; their crossings of detail are marked in turn and straight lines are run between them. The process is continued until a sufficient number of lines and marks have been established on the ground to enable all houses, roads, fences, streams, railways, canals, rivers, boundaries, and other detail to be conveniently measured up to and fixed. Perpendicular offsets are limited to eighty aud twenty links for the respective scales of 6 inches to a mile and 1/2500

(*b*) *Detail Surveying by Traverses.—*When a considerable area has to be thus treated it is divided into a number of blocks of con­venient size, bounded by roads, rivers, or parish boundaries, and a “ traverse on the meridian of the origin ” is carried round the peri­phery of each block. Commencing at a trigonometrical station, the theodolite is set to circle reading 0° 0' with the telescope point­ing to the north, and at every “forward” station of the traverse the circle is set to the same reading when the telescope is pointed at the “back” station as was obtained at the back station when the telescope was pointing to the forward one. When the circuit is completed and the theodolite again put up at the origin and set on the last back station with the appropriate circle reading, the circle reading, with the telescope again pointed to the first forward station, will be the same as at first, if no error has been committed. This system establishes a convenient check on the accuracy of the operations and enables the angles to be readily pro­tracted on a system of lines parallel to the meridian of the origin. Λs a further check the traverse is connected with all contiguous trigonometrical stations by measured angles and distances. Tra­verses are frequently carried between the points already fixed on the sides of the minor triangles; the initial side is then adopted, instead of the meridian, as the axis of coordinates for the plotting, the telescope being pointed with circle reading 0° 0' to either of the trigonometrical stations at the extremities of the side.

(c) *Plotting and Examination.—*The plotting is done from the field-books of the surveyors by a separate agency. Its accuracy is tested by examination on the ground, when all necessary addenda are made. The examiner—who should be both surveyor, plotter, and draftsman—mounts the plot on his sketching block, and verifies the accuracy of the detail by intersections and productions and occasional direct measurements, and generally endeavours to cause the details under examination to prove the accuracy of each other rather than to obtain direct proof by remeasurement. He fixes conspicuous trees and delineates the woods, footpaths, rocks, preci­pices, steep slopes, embankments, &c., and supplies the requisite information regarding minor objects—whether pit, shaft, level, spring, well, conduit, weir, quarry, refuse heap, waste, orchard, stack­yard, railway, canal, manufacturing and mineral works, viaducts, bridges, tramways, plantations, &c.—to enable a draftsman to make a perfect representation according to the scale of the map. In examining a coast-line he delineates the foreshore and sketches the strike and dip of the stratified rocks. In tidal rivers he ascertains and marks the highest points to which the ordinary tides flow. The examiner on the 25·344 inch scale ( = 1/2500) is required to give all necessary information regarding the parcels of ground of differ­ent character—whether arable, pasture, wood, moor, moss, sandy —defining the limits of each on a separate tracing if necessary. He has also to distinguish between turnpike, parish, and occupa­tion roads, to collect all names, and to furnish notes of military, baronial, and ecclesiastical antiquities to enable them to be ap­propriately represented in the final maps. The latter are sub­jected to a double examination,—first in the office, secondly on the ground ; they are then handed over to the officer in charge of the levelling to have the levels and contour lines inserted, and finally to the hill sketchers, whose duty it is to make an artistic representa­tion of the features of the ground.

(4) *Indian Survey Methods.—*All filling in is invariably done by plane-tabling on a basis of points previously fixed ; the methods differ simply in the extent to which linear measures are introduced to supplement the direction rays of the plane table. When the scale of the survey is small, direct measurements of distance are rarely made and the filling is usually done wholly by direction intersections, which fix all the principal points, and by eye-sketching ; but as the scale is increased linear measures with chains and offset poles are introduced to the extent that may be desirable. A sheet of drawing paper is mounted on cloth over the face of the plane table ; the points, previously fixed by triangulation or otherwise, are projected on it — the collateral meridians and parallels, or the rectangular coordinates, when these are more convenient for employment than the spherical, having first been drawn ; the plane table is then ready for use. Operations are commenced at a fixed point by aligning with the sight rule on another fixed point, which brings the meridian line of the table on that of

the station. The magnetic needle may now be placed on the table and a position assigned to it for future reference. Rays are drawn from the station point on the table to all conspicuous objects around with the aid of the sight rule. The table is then taken to other fixed points, and the process of ray-drawing is repeated at each ; thus a number of objects, some of which may become available as stations of observation, are fixed. Additional stations may be established by setting up the table on a ray, adjusting it on the back station—that from which the ray was drawn—and then ob­taining a cross intersection with the sight rule laid on some other fixed point, also by interpolating between three fixed points situated around the observer. The magnetic needle may not be relied on for correct orientation, but is of service in enabling the table to be set so nearly true at the outset that it has to be very slightly altered afterwards. The error in the setting is indicated by the rays from the surrounding fixed points intersecting in a small triangle instead of a point, and a slight change in azimuth suffices to reduce the triangle to a point, which will indicate the position of the station exactly. Azimuthal error being less apparent on short than on long lines, interpolation is best performed by rays drawn from near points, and checked by rays drawn to distant points, as the latter show most strongly the magnitude of any error of the primary magnetic setting. In this way, and by self-verificatory traverses “on the back ray” between fixed points, plane-table stations are established over the ground at appropriate intervals, depending on the scale of the survey ; and from these stations all surrounding objects which the scale permits of being shown are laid down on the table, sometimes by rays only, sometimes by a single ray and a measured distance. The general configuration of the ground is delineated simultaneously.

*Checking and Examination. —*Various methods are followed. For large scale work in plains it is customary to run arbitrary lines across it and make an independent survey of the belt of ground to a distance of a few chains on either side for comparison with the original survey ; the smaller scale hill topography is checked by examination from commanding points, and also by traverses run across the finished work on the table.

V. Representation of Ground.

The master lines of ground are the main ridges and water-partings of the hills, the watercourses, and the hori­zontal contour lines of the coasts ; the subordinate lines are those which define the undulations and minor features falling between the low-lying plains and the crests of the hills. These lines must first be laid down on a horizontal projection to fix the dimensions of each feature of the ground, after which the slopes must be indicated with sufficient relief and character to present a true picture of the corrugations of surface. In ancient maps the hills are represented as seen against the sky in profile by a spectator standing on the ground below at some distance off. This system of “ natural representation,” as it was called, was serviceable in enabling persons looking at the hills from the quarter from which they had been sketched to identify them readily, for which reason such views of distant inland hills are still commonly given on the margins of marine charts of coast-lines for the assistance of navigators. But, when all other objects except the hills are shown in a map by their horizontal projections, hills represented in perspec­tive are false to their surroundings, and misleading to all who approach them from other directions than that of the adopted point of view, for the vertical projection of the profile is practically turned over and confused with the horizontal plane. Hence in course of time hills came to be drawn as if seen from a high bird’s-eye point of view, the position of which was shifted until at last the point of sight was supposed to be vertically over them ; thus the evils of the perspective system were diminished, whilst something of natural representation was still preserved. About the end of the 18th century the perspective and the bird’s-eye systems gave way to the true method of indicating the forms of hills, viz., by their horizontal projections, like all the other details of the ground, and by adding the requisite shading to bring every feature into proper relief.

*Hill-Shading.—*There are two rival methods of hill-shad­ing,—one by horizontal contours, the other by vertical hachures. A contour being the line of intersection of a hill