of the sides and their lengths ultimately depend almost entirely upon the astronomical observations at the extremes of the survey; the observed true bearings and measured base are consequently more in the nature of checks than anything else. It is obvious, therefore, that the nearer together the observation spots, the greater effect will a given error in the astronomical positions have upon the length and direction of the sides of the triangulation, and in such cases the bearings as actually observed must not be altered to any large extent when a trilling change in the astronomical positions might perhaps effect the required harmony. For the reasons given under *Astronomical Base,* high land near observation spots may cause very false results, which may often account for discrepancies when situated on opposite sides of a mountainous country.

Great care is requisite in projecting on paper the points of a survey. The paper should be allowed to stretch and shrink as it pleases until it comes to a stand, being exposed to the air for four or five hours daily, and finally well flattened out by being placed on a table with drawing boards placed over it heavily weighted. If the triangulation has been calculated beforehand throughout, and the lengths of all the different sides have been found, it is more advantageous to begin plotting by distances rather than by chords. The main stations are thus got down in less time and with less trouble, but these are only a small proportion of the points to be plotted, and long lines must be ruled between the stations as zeros for plotting other points by chords. In τuling these lines care must be taken to draw them exactly through the centre of the pricks denoting the stations, but, however carefully drawn, there is liability to slight error in any line projected to a point lying beyond the distance of the stations between which the zero line is drawn. In plotting by distances, therefore, all points that will subsequently have to be plotted by chords should lie well within the area covered by the main triangulation. Three distances must be measured to obtain an intersection of the arcs cutting each other at a sufficiently broad angle; the plotting of the main stations once begun must be completed before distortion of the paper can occur from change in the humidity of the atmosphere. Plotting, whether by distance or by chords, must be begun on as long a side as possible, so as to plot *inwards,* or with decreasing distances. In plotting by chords it is impor­tant to remember in the selection of lines of reference (or zero lines), that that should be preferred which makes the smallest angle with the line to be projected from it, and of the angular points those nearest to the object to be projected from them.

*Irregular Methods of Plotting.—*In surveys for the ordinary purposes of navigation, it frequently happens that a regular system of triangulation cannot be carried out, and recourse must be had to a variety of devices; the judicious use of the ship in such cases is often essential, and with proper care excellent results may be obtained. A few examples will best illustrate some of the methods used, but circumstances vary so much in every survey that it is only possible to meet them properly by studying each case as it arises, and to improvise methods. Fixing a position by means of the back-angle " is one of the most ordinary expedients. Angles having been observed at A, to the station B, and certain other fixed points of the survey, C and D for instance; if A is shot up from B, at which station angles to the same fixed points have been observed, then it is not necessary to visit those points to fix A. For instance, in the triangle ABC, two of the angles have been observed, and there­fore the third angle at C is known (the three angles of a triangle being equal to 180°), and it is called the “ calculated or back-angle from C.” A necessary condition is that the receiving angle at A, between any'two lines (direct or calculated), must be sufficiently broad to give a good cut; also the points from which the “ back-angles ” are calculated should not be situated at too great distances from A, relatively to the distance between A and B. A station may be plotted by laying down the line to it from some other station, and then placing on tracing-paper a number of the angles taken at it, including the angle to the station from which it has been shot up. if the points to which angles are taken are well situated, a good position is obtained, its accuracy being much strengthened by being able to plot on a line to it, which, moreover, forms a good zero line for laying off other angles from the station when plotted. Sometimes the main stations must be carried on with a point plotted by only two angles. An effort must be made to check this subsequently by getting an “ angle back ” from stations dependent upon it to some old well-fixed point; failing this, two stations being plotted with two angles, pricking one and laying down the line to the other will afford a check. A well-defined mountain peak, far inland and never visited, when once it is well fixed is often invaluable in carrying on an irregular triangulation, as it may remain visible when all other original points of the survey have disappeared, and “ back-angles ” írom it may be continually obtained, or it may be used for plotting on true bearing lines of it. In plotting the true tearing of such a peak, the convergency must be found and applied to get the reversed bearing, which is then laid down from a meridian drawn through it; or the reversed tearing of any other line already drawn through the peak being known, it may simply be laid down with that as a zero. A rough position of the spot from which the true tearing was taken must be assumed in order to calculate the convergency. Fig. 11 will illustrate the foregoing remarks. A and B are astronomical observation spots at the extremes of a survey, from both of which the high, inaccessible peak C is visible. D, E, F are intermediate stations; A and D, D and E, E and F, F and B being respectively visible from each other. G is visible from A and D, and C is visible from all stations. The latitudes of A and B and meridian distance between them being determined, and the true bear­ing of C being observed from both

observation spots, angles are observed at all the stations. Calcu­lating the spheroidal correction (front the formula, correction = d. long. —-∙~~pj~~∙∙--'^-i- j and adding it to the true (or chronometric) difference longitude between A and B to obtain the spherical d. long.; with this spherical d. long. and the d. lat., the Mer- catorial true bearing and distance is found by middle latitude sailing (which is an equally correct but shorter method than by spherical trigonometry, and may be safely used when dealing with the distances usual between observation spots in nautical surveys). The convergency is also calculated, and the true bearing of A from B and B from A are thus determined. In the plane triangle ABC the angle A is the difference between the calculated tearing of B and the observed bearing of C from A ; similarly angle B is the difference between calculated tearing of A and observed tearing of C from B. The distance AB having been also calculated, the side AC is found. Laying down AC on the paper on the required scale, D is plotted on its direct shot from A, and on the angle back from C, calculated in the triangle ACL). G is plotted on the direct shots from A and D, and on the angle back from C, calculated either in the triangle ACG or GCD. The perfect intersection of the three lines at G assures these four points being correct. E, F and B are plotted in a similar manner. The points are now all plotted, but they depend on calculated angles, and except for the first four points we have no check whatever either on the accuracy of the angles observed in the field or on the plotting. Another well-defined object in such a position, for instance as Z, visible from three or more stations, would afford the necessary check, if lines laid off to it from as many stations as possible gave a good intersection. If no such point, however, exists, a certain degree of check on the angles observed is derived by applying the sum of all the calculated angles at C to the true bearing of A from C (found by reversing observed bearing of C from A with convergency applied), which will give the bearing of B from C. Reverse this bearing with convergency applied, and compare it with the observed tearing of C from B. If the discrepancy is but small, it will be a strong presumption in favour of the substantial accuracy of the work. If the calculated true bearing of B from A be now laid down, it is very unlikely that the line will pass through B, but this is due to the discrepancy which must always be expected between astronomical positions and trian­gulation. If some of the stations between A and B require to be placed somewhat closely to one another, it may be desirable to obtain fresh true bearings of C instead of carrying on the original bearing by means of the calculated angle.

In all cases of irregular plotting the ship is very useful, especially if she is moored taut without the swivel, and angles are observed from the bow. Floating beacons may also assist an irregular triangulation.

Surveys of various degrees of accuracy are included among sketch surveys. The Toughest description is the ordinary running survey, when the work is done by the ship steaming along the coast, fixing points, and sketching in the coast-line by bearings and angles, relying for her position upon her courses and distances as registered by patent log, necessarily regardless of the effect of wind and current and errors of steerage. At the other extreme comes the modified running survey, which in point of practical accuracy falls little short of that attained by irregular triangulation. Some of these modifications will be briefly noticed. A running survey of a coast-line between two harbours, that have been surveyed inde­pendently and astronomically fixed, may often be carried out