objects being not less than 30° or more than 140°. The amount of the angle between the middle and distant object is immaterial. (*b*) The three objects nearly in a straight line, the angle between any two being not less than 30°. (*c*) The observer’s position

being inside the triangle formed by the objects.

A fix on the line of two points in transit, with an angle to a third point, becomes more sensitive as the distance between the transit points increases relatively to the distance between thc front transit point and the observer; the more nearly the angle to the third point approaches a right angle, and the nearer it is situated to the observer, the better the fix. If the third point is at a long distance, small errors either of observation or plotting affect the result largely. A good practical test for a fix is afforded by noticing whether a very slight movement of the centre of the station-pointer will throw one or more of the points away from the leg. If it can be moved without appreci­ably disturbing the coincidence of the leg and all three points, the fix is bad.

Tracing-paper answers exactly the same purpose as the station-pointer. The angles are laid off from a centre representing the position, and the lines brought to pass through the points as before. This entails more time, and the angles are not so accurately measured with a small protractor. Nevertheless this has often to be used, as when points arc close together on a small scale the central part of the station-pointer will often hide them and prevent the use of the instrument. The use of tracing-paper permits any number of angles to different points to be laid down on it, which under certain conditions of fixing is sometimes a great advantage.

Although marine surveys are in reality founded upon triangula­tion and measured bases of some description, yet when plotted irregularly the system of triangles is. not always apparent. The triangulation ranges from the rough triangle of a running survey to the carefully formed triangles of detailed surveys. the measured base for an extended survey is provisional only, the scale resting ultimately mainly upon the astronomical positions observed at its extremes. In the case of a plan the base is absolute. The main triangulation, of which the first triangle contains the measured base as its known side, establishes a series of points known as main stations, from which and to which angles are taken to fix other stations. A sufficiency of secondary stations and marks enables the detail of the chart to be filled in between them. The points embracing thc area to be worked on, having been plotted, are transferred to field boards, upon which the detail of the work in the field is plotted; when complete the work is traced and re-transferred to the plotting-sheet, which is then inked in as the finished chart, and if of large extent it is graduated on the gnomonic projection on the astronomical positions of two points situatcd near opposite corners of the chart.

The kind of base ordinarily used is one measured by chain on flat ground, of 1/2 to 11/2 m. in length, between two points visible from one another, and so situated that a triangulation can be readily extended from them to embrace other points in the survey forming well-conditioned triangles. The error of the chain is noted before leaving the ship, and again on returning, by com­paring its length with the standard length of 100 ft. marked on the ship’s deck. The correction so found is applied to obtain the final result. If by reason of water intervening between the base stations it is impossible to measure the direct distance between them, it is permissible to deduce it by traversing.

*A Masthead Angle Base* is useful for small plans of harbours, &c., when circumstances do not permit of a base being measured on shore. The ship at anchor nearly midway between two base stations is the most favourable condition for employing this method. Theodolite reading of the masthead with its elevation by sextant observed simultaneously at each base station (the mean of several observations being employed) give the necessary data to calculate the distance between the base stations from the two distances resulting from the elevation of the masthead and the simultaneous theodolite-angies between the masthead and the base stations. The height of the masthead may be temporarily increased by secur­ing a spar to extend 30 ft. or so above it, and the exact height from truck to netting is found by tricing up the end of the measuring chain. The angle of elevation should not be diminished below about 1° from either station.

*Base by Sound.—*The interval in seconds between the flash and report of a gun, carefully noted by counting the beats of a watch or pocket chronometer, multiplied by the rate per second at which sound travels (corrected for temperature) supplies a means of obtaining a base which is sometimes of great use when other methods are not available. Three miles is a suitable distance for such a base, and guns or small brass Cohorn mortars are fired alternately from either end, and repeated several times. The arithmetical mean is not strictly correct, owing to the retardation of the sound against the wind exceeding the acceleration when travelling with it; the formula used is therefore T = 2*tt'*/*t*+*t'*, where T is the mean interval required, *t* the interval observed one way, *t'* the interval the other way. The method is not a very accurate one, but is suffi­ciently so when the scale is finally determined by astronomical observations, or for sketch surveys. The measurement should be across the wind if possible, especially if guns can only be fired from one end of the base. Sound travels about 1090 ft. per second at a temperature of 32° F., and increases at the rate of 1∙15 ft. for each degree above that temperature, decreasing in the same proportion for temperatures below 32°.

*Base by Angle of Short Measured Length.—*An angle measured by sextant between two well-defined marks at a carefully measured distance apart, placed at right angles to the required base, will give a base for a small plan.

*Astronomical Base.—*The difference of latitude between two stations visible from each other and nearly in the same meridian, combined with their true bearings, gives an excellent base for an extended triangulation; the only drawback to it is the effect of local attraction of masses of land in the vicinity on the pendulum, or, in other words, on the mercury in the artificial horizon. The base stations should be as far apart as possible, in order to minimize the effect of any error in the astronomical observations. The obser­vation spots would not necessarily be actually at the base stations, which would probably be situated on summits at some little distance in order to command distant views. In such cases each observation spot would be connected with its corresponding base station by a subsidiary triangulation, a short base being measured for the pur­pose. The ship at anchor off the observation spot frequently affords a convenient means of effecting the connexion by a masthead angle base and simultaneous angles. If possible, the observation spots should be east or west of the mountain stations from which the true bearings are observed.

If the base stations A and B are so situated that by reason of distance or of high land intervening they are invisible from one another, but both visible from some main station C between them, when the main triangulation is completed, the ratio of the sides AC, BC can be determined. From this ratio and the observed angle ACB, the angles ABC, BAC can be found. The true bearing of the lines AC or BC being known, the true bearing of the base stations A and B can be deduced.

*Extension of Base.—*A base of any description is seldom long enough to plot from directly, and in order to diminish errors of plotting it is necessary to begin on the longest side possible so as to work *inwards.* A short base measured on flat ground will give a better result than a longer one measured over inequalities, provided that the triangulation is carefully extended by means of judiciously selected triangles, great care being taken to plumb the centre of each station. To facilitate the extension of the base in as few triangles as possible, the base should be placed so that there are two stations, one on each side of it, subtending angles at them of from 30° to 40°, and the distances between which, on being calculated in the triangles of the quadrilateral so formed, will constitute the first extension of the base. Similarly, two other stations placed one on each side of the last two will form another quadrilateral, giving a yet longer side, and so on.

The angles to be used in the main triangulation scheme must be very carefully observed and the theodolite placed exactly over the centre of the station. Main angles are usually repeated several times by resetting the vernier at intervals equidistant along the arc, in order to eliminate instrumental errors as well as errors of observation. The selection of an object suitable for a zero is important. It should, if possible, be another main station at some distance, but not so far or so high as to be easily obscured, well defined, and likely to be permanent. Angles to secondary stations and other marks need not be repeated so many times as the more important angles, but it is well to check all angles once at least. Rough sketches from all stations are of great assistance in identifying objects from different points of view, the angles being entered against each in the sketch.

*False Station.—*When the theodolite cannot for any reason be placed over the centre of a station, if the distance be measured