their bulbs are outside, and more slowly if inside the bar. Thus there is always more or less lagging, and its effects are only eliminated when the rises and falls are of equal amount and duration ; but as a rule the rise generally predominates greatly during the usual hours of work, and whenever this happens lagging may cause more error in a base-line measured with simple bars than all other sources of error combined. In India the probable average lagging of the standard-bar thermometer was estimated as not less than 0°·3 Fahr., corresponding to an error of - 2 millionths in the length of a base-line measured with iron bars. With compound bars lagging would be much the same for both components and its influence would consequently be elimi­nated. Thus the most perfect base-line apparatus would seem to be one of compensation bars with thermometers attached to each component ; then the comparisons with the standard need only be taken at the times when the temperature is constant, and there is no lagging.

3. *Factor of Expansion of Standard Bar.—*This was first determined in 1832 by measuring the increment in length between temperatures of 76° and 212° Fahr.; in 1870 the increment between 52° and 96° was measured; the results indicated an increase of expansion with tem­perature. They were therefore combined on the empirical assumption that the expansion is the sum of two terms,— the first *x* times the temperature, the second *y* times the square of the temperature ; *x* and *y* were then determined from the two equations of condition given by the two sets of measurements. The resulting value of the expansion at 62° was found to be 5 per cent. less than the previously derived value at the mean temperature of 144°, thus show­ing the importance of employing a factor varying with the mean temperature of each base-line; and this was done in the final reductions.

4. *Plan of Triangulation.—*This was broadly a system of internal meridional and longitudinal chains with an ex­ternal border of oblique chains following the course of the frontier and the coast lines. The design of each chain was necessarily much influenced by the physical features of the country over which it was carried. The most diffi­cult tracts were plains of great extent, devoid of any com­manding points of view, in some parts covered with dense forest and jungle, malarious and deadly, and almost unin­habited, in other parts covered with towns and villages and umbrageous trees,—the adjuncts and concomitants of a teeming population. In such tracts triangulation was impossible except by constructing lofty towers as stations of observation, raising them to a sufficient height to over­top at least the earth’s curvature, and then either increas­ing the height to surmount all obstacles to mutual vision, or clearing the lines, both of which were laborious and expensive processes. Thus in hilly and open country the chains of triangles were generally made “double” through­out, *i.e.,* formed of polygonal and quadrilateral figures, to give greater breadth and accuracy; but in tracts of forest and close country they were carried out as series of single triangles, to give a minimum of labour and expense. Symmetry was secured by restricting the angles between the limits of 30° and 90°. The average side length was 30 miles in hill country and 11 in the plains ; the longest principal side was 62·7 miles, though in the secondary triangulation to the Himalayan peaks there were sides exceeding 200 miles. Long sides were at first considered desirable, on the principle that the fewer the links the greater the accuracy of a chain of triangles ; but it was eventually found that good observations on long sides could only be obtained under exceptionally favourable atmospheric conditions, which were of rare occurrence. The sides were therefore shortened, whereby the observa­tions were much improved and accelerated. In plains the

length was governed by the height to which towers could be conveniently raised to surmount the curvature, under the well-known condition, height in feet — 2/3 × square of the distance in miles ; thus 24 feet of height was needed at each end of a side to overtop the curvature in 12 miles, and to this had to be added whatever was required to surmount obstacles on the ground. In Indian plains re­fraction is more frequently negative than positive during sunshine ; no reduction could therefore be made for it.

5. *Selection of Sites for Stations.—*This, a very simple matter in hills and open country, is often very difficult in plains and close country. In the early operations, when the great arc was being carried across the wide plains of the Gangetic valley, which are covered with villages and trees and other obstacles to distant vision, masts 35 feet high were carried about for the support of the small re­connoitring theodolites, with a sufficiency of poles and bamboos to form a scaffolding of the same height for the observer. Other masts 70 feet high, with arrangements for displaying blue lights by night at 90 feet, were erected at the spots where station sites were wanted. But the cost of transport was great ; the rate of progress was slow ; and the results were unsatisfactory. Eventually a method of touch rather than sight was adopted, feeling the ground to search for the obstacles to be avoided, rather than attempting to look over them ; the “ rays ” were traced either by a minor triangulation, or by a traverse with theodolite and perambulator, or by a simple alignment of flags. The first method gives the direction of the new station most accurately ; the second searches the ground most closely ; the third is best suited for tracts of unin­habited forest in which there is no choice of either line or site, and the required station may be built at the inter­section of the two trial rays leading up to it. As a rule it has been found most economical and expeditious to raise the towers only to the height necessary for surmounting the curvature, and to remove the trees and other obstacles on the lines.

6. *Structure of the Principal Stations.—*Each has a cen­tral masonry pillar, circular and 3 to 4 feet in diameter, for the support of a large theodolite, and around it a plat­form 14 to 16 feet square for the observatory tent, observer, and signallers. The pillar is carefully isolated from the platform, and when solid carries the station mark—a dot surrounded by a circle—engraved on a stone at its surface, and on additional stones or the rock *in situ,* in the normal of the upper mark ; but, if the height is considerable and there is a liability to deflexion, the pillar is constructed with a central vertical shaft to enable the theodolite to be plumbed over the ground-level mark, to which access is obtained through a passage in the basement. In early years this precaution against deflexion was neglected and the pillars were built solid throughout, whatever their height ; the surrounding platforms, being usually con­structed of sun-dried bricks or stones and earth, were liable to fall and press against the pillars, some of which thus became deflected during the rainy seasons that intervened between the periods during which operations were arrested or the commencement and close of the successive circuits of triangles. In some instances displacements of mark occurred of which the magnitudes were not ascertainable, but were estimated as equivalent to *p.e.'*sof about ±9 inches in the length and± 2"·4 in the azimuth of the side between any two deflected towers ; and, as these theoretical errors are identical with what may be expected at the end of a chain of 36 equilateral triangles in which all the angles have been measured with *ap.e.* = ± 0"·5, the old triangula­tion over solid towers had evidently suffered much more from the deflexions of the towers than from errors in the measurements of the angles.