City Survey Manual

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सप्तर्षी प्रकाशन

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CITY SURVEY MANUAL

CHAPTER I.

Introductory.

City Surveys are carried out under the provisions of L.R.C. Sections 131-133 which invoke also Sections 95, (96 and 97 if the town has a population not exceeding 2,000) 100, 102-108, 119-121 and 126; while Revisions can be carried out under Section 106. The former law was the Survey Act of 1863 and Act IV of 1868. The general policy of Government in introducing such Surveys is found in R. 995-10. As long ago as para. 4 of R. 3921-67 it was pronounced that it is as much the duty of Government to survey cities and village sites as to survey agricultural lands.

2. The objects are threefold and may be described as Administrative, Fiscal, and Legal. The Administrative object is to provide an accurate map of topographical detail and of occupied houses and offices, &c., for Postal, Municipal, Sanitary, Police and Census purposes. Schemes for water-supply, drainage, tramways, electric light or gas, telephones, and the like, of necessity require a complete and fairly large scale map; while the organisation of schools, medical relief and vital statistics, fire protection, octroi and toll administration, all depend upon an accurate and detailed map.

3. The Fiscal object is to ascertain the revenue due from land and to watch over the development of future revenue, and to protect public land against encroachment and wholesale or furtive appropriation.

4. The Legal object is to clear all titles to existing holdings; to support and better define those which are good, and to eliminate those which are bad; to prevent vexatious litigation between owners and to remove doubts and similar possible litigation between private claimants and local bodies or Government.

5. The mere mapping of streets and open spaces would, therefore, plainly be of small utility and cannot possibly suffice in view of Section 132 (R. 995-10, 6315-14). There is little revenue at present derived from town lands, and the benefit to Government under the Fiscal head is not great but the benefits to the public and the inhabitants of the town, especially to the holders of land, under the Administrative and Legal heads are very great, and in view of this and of the great facility which such Surveys give for further development and consequent improvement in the value of real property, we are justified in charging the cost of the Survey upon the owners. Formerly under Act IV of 1868, Municipalities were invited to bear a substantial part, or sometimes even the whole, of the cost. But it was found necessary to grant them concessions of shares in the revenue or rights over unoccupied land, the future value of which it would be very hard to estimate and it is now decided that in any such future Surveys the Municipality will not be asked to contribute or even to bear any part of the cost of the maintenance (F. 968-13 and R. 685-16). As representatives of the real property holders they derive all the Administrative benefits; and when they hold land for purposes from which they derive revenue like ordinary landholders they also pay their share as holders of real property (R. 5000-16, para. 3, and R. 11155-16 para. 2) but are exempt in respect of such lands as they hold for Municipal purposes, such as roads, schools, hospitals, fire stations, and so on; whether they should pay fees in respect of the latter class also is under discussion.

6. The provisions of the City Survey law apply only to non-agricultural land. Frequently, however, we find lands still used for agriculture interspersed between the building sites. The boundaries between the two classes of land are of course necessarily mapped in the City Survey, but the Survey has no effect upon the agricultural land. Since, however, Government order that a City Survey shall be applied to all lands other than those used ordinarily for purposes of agriculture, it would follow that as soon as the interspersed lands

within the limits to which the City Survey was applied are in their turn converted from agriculture to other uses, then the City Survey law is, as it were, lying in wait for them, and the individual plots so formed in the blanks or islands left in the original map will at once be mapped in detail, and Sanads will be issued and Sanad fees levied from time to time, fresh notice being given under Clause 2 of Section 132 for each such newly mapped part of the town It is at the same time usual (R. 6106-17) also to extend Chaptet X-A of the Code (the Record of Rights) to all surveyed areas; therefore, whenever any land is subdivided and has to be mapped within such an area (even if the City Survey be held not to apply to it without a fresh notification) a fee for the mapping of the freshly formed plots can always be levied under Section 135-G (*b*): so it becomes immaterial whether the fee is charged as a Sanad fee under Section 132, or under the Record of Rights law. But since there is no limit even of Rs. 10 to the amount that can be charged under Section 135-G, it is expedient for the proprietor to elect to be dealt with under Section 132.

7. The area to which such a Survey may extend is defined as "the village, town, or city site," but Section 126 gives the Collector power to declare what the limits of the site are. There can be no doubt that this was not intended to empower the Collector to include great stretches of agricultural or other land which are not actually occupied by the city or town site. He is empowered to declare how far the site extends when there is reasonable room for some doubt upon the point. Quite obviously we cannot stringently follow the exact limits of existing buildings; there must be a certain fringe perhaps not yet covered with buildings but likely to be so covered soon. He cannot declare that land to be a town site which plainly and conspicuously is not.

8. The power of extending the site under Section 126 always remains, and when such an extension is effected and notified it requires only a routine notification to extend the City Survey to it. The mapping of such additional area can very easily be carried out by the normal maintenance staff and joined with precision on to the existing maps, as will hereafter be seen. Therefore, nothing is gained by extending the first Survey beyond reasonable limits, and the argument that large stretches of agricultural land are likely to come under town planning or development for industrial purposes after an indefinite number of years is quite inadequate. Moreover, it is usually very wasteful to map such outlying areas,* *especially* such as are likely to come under any kind of town planning or re-arrangement of roads; because as soon as those new roads and lanes and lines of houses are laid out, any past attempt to map the area in detail is wasted and has to be rubbed out and replaced by the new layout. Even the theodolite stations would disappear under new buildings (*see* para. 171). Since, therefore, there exist almost everywhere cadastral maps of the Revenue Survey which give us all reasonable detail about the agricultural lands which surround the city, and since we can equitably charge no fee for *again* mapping these lands, it is inexpedient to go beyond the strict intention of Section 131 when determining the limit to which our City Survey should extend.

9. Nor is there any need of causing the boundary to agree with the Municipal boundary. Municipalities often hold within their control large areas of sewage farms or water-works and the like far from the city, and they also have control over surrounding lands for sanitary purposes. This constitutes no reason for extending City Survey to those limits.

10. The procedure, therefore, for introducing a City Survey is that either the Collector or the Municipality advance or endorse a proposal that the city should be surveyed. If this is accepted upon general grounds, then the Director of Land Records frames an estimate of the probable cost, which it is hoped under the procedure and methods to be detailed in this Manual will very rarely exceed an average of Rs. 2 per property, and should be capable of being kept down to about Rs. 1½ or even lower. This will mean Sanad fees ranging from 8 annas for the small properties up to Rs. 1½ for the average small house and then ranging up from Rs. 2 to 10 for the larger and more valuable properties. The cost of the Survey as estimated must include map printing both for the

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* It took 32 days' work to incorporate 25 outlying scattered buildings at Nandurbar.

issue of Sanads and for the purpose of the map itself, since no Survey is of Administrative use until reduced to a consolidated map. Upon consideration of these estimates, the Commissioner may then obtain the sanction of Government to the Survey, and should it be desired to extend the Survey beyond the stereotyped and ancient boundaries of the Gaothan or city site, the Collector will issue his notification under Section 126; and Government will then finally sanction the Survey under Section 131. Having thus been legally sanctioned, it must next be provided for in the Budget of Revenue Advances which is sent to the Commissioner in October. It will ordinarily be nearly two years, and may sometimes even be longer before any recoveries can be made, since the issue of the Sanads and the collection of the fees is the last step of all. Therefore, the full cost must be estimated and budgetted for as a Revenue Advance, and all recoveries will of course be taken to the same head until the advance is adjusted, or any surplus or deficit recovery is settled by order of the proper authority. The Collector could transfer to the credit of Government any trifling excess in the recovery which is very unusual, while the orders of Government are needed for writing off any deficit (*see* R. 11155-16). The budget having been sanctioned, the Superintendent of Land Records would then arrange to start work as soon as he has staff available, by deputing men from his Field Party. First he must provide equipment and office accommodation. The Collector arranges to advise people generally, while the Enquiry Officer will issue more specific notices when he commences his work. It is desirable that the Enquiry Officer should be appointed at a fairly early stage, so that he may not only carry out the Enquiry, but may also keep some watch over the general administration of the Survey, since the S. L. R. cannot remain always present. It will be seen hereafter that when more than 5 detail measurers are to be employed they can begin work 10 to 15 days after traversing starts, and the Enquiry can begin a week after Detail Mapping starts, without fear of overtaking it. All expenditure, whatever, is drawn upon bills debited to Revenue Advances, City Survey of—. The Head Surveyor has a permanent advance for petty expenditure, while monthly bills for salaries and contingencies and bonus, &c., to recoup that permanent advance or for direct disbursement must be passed by S. L. R. Sanction must be obtained for the purchase of deadstock, and all usual office accounts must be kept. A scale of output is fixed, and diaries are submitted by each Branch. Similarly, all recoveries are credited to the City Survey head; not only the Sanad fees, but also bhatta paid by Courts to City Survey employees as witnesses, fines, sale of useless deadstock, copy fees and comparing fees (when the work is done by the City Survey staff), and even extra fees for Sanads not taken up at the proper time [Section 133 (2)]. When this work of delivering Sanads is performed by the Revenue staff after the disbanding of the City Survey, these extra fees are sometimes claimed as ordinary Misc. Land Revenue, but when the amount is substantial the City Survey ought to receive credit for these extra fees (perhaps deducting the cost of extra Revenue staff employed to realise them), unless the full Survey cost has already been covered by the ordinary Sanad fees. The price realised for land found to have been encroached upon or other revenue realised from the land as a result of the Survey cannot be credited against the City Survey advances; though it may be taken into account in computing the general advantages and general financial results of the Survey.

11. The actual operations of the Survey fall into several parts. There is the actual measuring and mapping which we describe under the separate heads of Traversing and Detail Mapping. Then there is the Enquiry in which the correct limits and frontages of all properties, and their ownership, are finally settled; the result of appeals when made must of course be awaited. Then, on completion of the enquiry, maps must be corrected to agree with the limits found by E. O. or the appellate authority. Then the detailed maps are traced and printed, and a general map is prepared by joining them together, and also the printed detailed maps are cut up to be affixed to the Sanads which are issued for each property. Then the Sanads will be issued and fees collected, and the Property Register will be written up upon the final result of the Enquiry. Then the whole work is handed over to the Maintenance staff, which must commence work without any interval; *see* Sir F. G. Burrard's remarks in R. 5277-14. Strictly speaking, the maintenance of each sheet ought to

commence on the day the enquiry for that sheet is completed. In large cities, if an interval is allowed to elapse, it will be difficult and troublesome to catch up the changes which are taking place almost every day.

12. Under the influence of weather and white-ants and other pests, ordinary houses in ordinary towns do not last more than about 50 years, while even good houses will not last 100 years. There are also fires and fresh enterprises such as roads or railways or extensive remodelling which alter the whole layout of considerable areas. Tramways and railways and new mills and industries produce many alterations in the appearance of a city. There is also a constant flow of legal changes. In the past, the neglect to maintain our City Survey maps and the Property Records abreast of all these changes has rendered all the Surveys useless within 50 years of their completion. It is plainly undesirable that money should be so spent and then its fruits wasted. The public require and are entitled to have a day-to-day maintenance which will not be thrown out of gear by any of these changes. The Survey should give us a starting point with dated maps, the originals of which will not be altered. Thereafter every change must be incorporated in the *printed* maps as rapidly as it occurs, and this Maintenance staff cannot be passive or sedentary, merely waiting in an office until information is brought, but it must move about and look for the changes which are not reported as well as receiving those which are reported. Throughout the whole of our City Survey operations we must have an eye upon the final object and upon the requirements of Maintenance.

13. After this general sketch of the operations, we will now consider each step in detail. The chapters we require will be these :—

Traversing.

Detail Mapping.

The final Numbering and Arrangement of Sheets.

Notes on Titles, Possession, Streets, Easements.

Powers of Enquiry Officers; Procedure and Appeals.

Map Printing.

Sanads and Property Register; and the Separation of Properties.

Fee-Calculation and Recovery.

Maintenance and Revenue Accounts in City-Surveyed Areas.

CHAPTER II.

Traversing.

14. Before we commence any measurement we must set before us a conception of what we ultimately require. We shall need a general map of the whole city on a scale of 200 ft. to the inch, a very convenient scale for a wall map; and this sheet must be compiled from a number of detailed sheets on a larger scale of 40 or even 25 feet to the inch, which can be united and reduced into the general map. Each one of these detailed sheets must show the exact position of all the boundaries of all properties and unclaimed spaces, of all streets and buildings and topographical points such as rivers and hills and everything else which we want to map in the city. We may, therefore, say that the detailed maps require to show the exact position of every significant point in the city. Now, to fix the position of a point with reference only to surrounding points is not enough. The frame work is too fragile, uncertain and unconvincing. We must so fix it that we can restore that point *independently* of any other point, if the need arises. Of course, we have the opposite side of the street and adjacent buildings upon which sometimes we can rely. But that is not enough. Re-building and expansion going on for centuries will ultimately destroy every reference point upon which we might have relied for the determination of the point in question.

15. A point is uniquely determined when its exact position with respect to a base line is known, if that base line is in turn connected with a mathematically determined frame work, capable of restoration not from any terrestrial point but from the fixed stars alone. The Great Trigonometrical Survey consists of a series of triangles so connected. If one station were obliterated, no doubt it could be restored with facility from adjacent stations. But when a whole series of stations is destroyed, the process becomes more difficult and each station has its latitude and longitude so accurately determined that it can be restored from the fixed stars even though its former location has been buried by earthquake, flood, or any other commotion. When a station can be restored in this way and the base lines founded upon it can similarly be restored and likewise any point related to those base lines, then we are in a position not only to restore doubtful points but to prove absolutely, without reference to anything terrestrial, the exact correctness of our restoration. Now, it is very unlikely that in any city there could be such a simultaneous and wholesale destruction of reference points as to make it in practice necessary to go back to the fixed stars. We want to lay down and preserve a frame work based on astronomical relations but still demarcated and triangulated, so that small portions or sections of it can be instantly relaid without any thought of astronomy. And we must take pains to prevent as much as we can even the commencement of the loss of any of the important reference points in the frame work.

16. We require, therefore, to cover the city with a net work of points and lines which can be represented on paper on a predetermined scale and upon which base lines can be drawn and every intervening point can be plotted upon that determined scale, and to connect the whole with the Great Trigonometrical Survey. Now, in a flat plain devoid of obstacles, such a net work could be laid down in almost any direction, since every point will be visible from every other. But in a city we cannot see through houses. The Trigonometrical Survey escapes the difficulty by triangulating from hilltop to hilltop above the obstacles. We cannot do this; therefore, we must choose lines of sight through the city which are open and which are most likely to remain open. Survey lines can be laid down even through dense forest by cutting away trees, but such lines once cleared are very likely to close up again very soon, so that the Survey though useful for the immediate purpose for which it was undertaken will cease to be of any future use, unless enormous trouble be taken to re-open the Survey lines. But in a city, the lines which are least likely to be closed are the established public streets, because many interests combine to keep them open, except in those cases where certain lengths of street are replaced by new and

improved streets. This is a contingency, however, which will cause us very little difficulty. Therefore, we first choose the streets as the lines along which we will lay our frame work, until of course we find some large open spaces in which we can range more freely : even then we must have regard to the probable location of future streets.

17. The frame work must consist of lines of known length related to one another by known angles, and in order to assist in finding them we must demarcate the ends of each line. Of course we could always find the base by measurement and fresh observation of the angles, but the time and labour which this would be continually consuming is so great that demarcation dare not be omitted. Having chosen the points for these lines to run through and about the city, we must next link them all together mathematically so that they can be transferred to paper with such a record that at any time we can replot or relay any part of that frame work, and can strictly and legally prove the accuracy of the mapping. This operation of going through or traversing the city with survey lines is known as "Traversing." If we start from a known point and travel in a known direction for a known number of feet, then bury a stone and then turn in a new direction and travel a further distance and so on; it is clear that for each length we measure there may be a trifling error of measurement and each time we change our direction there may be a trifling error in the angle. Therefore, we do these operations in such a way that we return to the starting point, making thus what is called a closed traverse and then we shall be able to see that the lines as plotted on paper do actually come back to the starting point exactly as the lines on the ground in fact do come back. The method of traversing which we shall use is what is known as Gale's Closed Traverse, and to make its nature quite clear we will take a very simple case first as in Fig. I. We will suppose that we have three buildings to survey, and we take 3 points A, B, C all visible from one another along legs so "traversing" the area upon which the buildings lie that we shall be able to determine the exact position of every point in these buildings from those legs as base lines. We must also remember that when we transfer these buildings and the base lines to our paper map we want to orient them all in their correct position with reference to the points of the compass: north, south, east and west. These are the problems of the City Survey whether there be 3 buildings or 30,000, and whether the traverse sides are the minimum number of 3 or whether they run into hundreds.

18. The method is this: first, we must put down at the chosen points A, B, and C, stones firmly fixed in the ground upon which a mark (cross or circle) is cut showing the exact centre upon which observations are taken. Then place flags or other marks* visible from B upon the stones A and C. Upon B set up the Theodolite, which is an instrument carrying a telescope on a tripod so accurately pivoted that if we first sight A through the telescope, getting the fine cross-wires in the lens exactly upon A and then turn the telescope until C intersects the same cross-wires, the exact angle ABC is read off upon a scale with a vernier and microscope. The Theodolites used in C.T.S. do not read smaller subdivisions of an angle than 1 minute. We will henceforth use the notation:—°degree ; ′minute; ″second. For 1° there are 60′ and 3,600″. In a right angle there are, therefore, 5,400′ and 324,000″. It is clear from Fig. II that 1′ is a smaller angle than can be drawn with pen or pencil, and seconds are too small to think about in city mapping. We find the interior angle ABC to be 62° 10′ but as we cannot read the fractions of a minute, this may really be 30″ more or less. As another precaution we also read the exterior angle ABC which ought to be 297° 50′. But if we find the vernier reads rather nearer to 297° 49′ then we may again read the inner angle and might decide to put it at 62° 9½′. The exact technical way of setting up the Theodolite and levelling it and setting its screws and reading the vernier will be found described in Thuillier, Boileau or any standard work: and Mr. R. G. Gordon's Manual of Surveying.

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* In Theodolite work, marks must be sharp, not exceeding ⅛″ in diameter, and must be observed as close to the ground as possible.

This method requires us (1) to sight A from B with the vernier of the upper plate clamped at zero, the lower plate being, of course, free: then after loosening the upper and tightening the lower plate, we swing the telescope round right handed or clockwise (the instrument being right-handed) till it covers C. Then read the (exterior) angle on the vernier. (2) Then loosen the lower plate and again fix the vernier at zero with the telescope still bisecting C. Then clamp the lower plate and continue to swing the telescope right-handed to A. Then read the (interior) angle. Thus we read each angle on a different part of the graduated limb, and doubly check the correctness of each. This is better than most of the text book methods. (*N.B.*—With a left-handed Theodolite the directions would be reversed throughout.)

19. Since we want to know the exact relation of the traverse to the north point, we must at some of our stations observe the angle made by the line of sight between two stations with the magnetic north or astronomical north, for which the Pole-star (which lies at a distance of 33′ from the true Pole: *see* para. 26) might be observed if the Theodolite is kept in position until after dark. But in Bombay Presidency the difference between astronomical and magnetic north is too small (from 1° E. in Kathiawar to 42′ W. at Dharwar with seasonal and diurnal variations of ± 4′) to be worth noticing. If we take the north point with a magnetic compass it cannot be observed with very great fineness, certainly not more closely than 10′ and if we took the same observation at every station of the traverse, we should be likely to obtain small differences at each station. The best practice, therefore, is to observe the magnetic north point several times at one station only and calculate the north for every other station arithmetically, from the azimuth of the observed leg.

20. Having finished our observations at B, we repeat the process at C and there find the angle ACB to be 43° 47′. We also measure the exact distance in feet and inches from A to B, and from B to C, and from C to A. Then we proceed back to station A to perform the "closing" of the traverse. We can (since the angles at B and at C are known) calculate the angle at A by the well known rule that the three interior angles of the triangle must be equal to two right angles or 180°. But if we have made an error in observing the angle at B and the angle at C, and then simply calculate the angle at A, we should never discover the error. We, therefore, *observe* it and see whether it comes exactly right or not. We may find it to be 1′ more than by calculation it should be. Clearly then we must have taken in the other angles fractions of a minute too much, so that B should strictly speaking be 62° 9½′, and C should be 43° 46½′, or there may be ½′ error in our observation at A. Still it will be better to have one of the angles a fraction of a minute too small than to keep A a whole minute too much. So we distribute the difference over the other angles by knocking off fractions or by reducing a minute here or there, until we get a correct closure of the angles. If there were not 3 sides but 13 or 30, still the method is just the same. We observe all the interior angles, double-checking each by the exterior reading also; then we find out what the last angle ought to be and what it actually is; and we adjust the difference by knocking off or adding a minute here or there to any angles we choose. An error of 1′ in one angle is negligible, but an accumulated error of several minutes in the last or closing angles would be material. If the error is greater than can be so adjusted (*i.e.*, if it exceeds an average of ½′ multiplied by the square root of the number of the angles observed), but through some carelessness we get an error of 2° or 3°, then we must go over the traverse again until we find where the error has been made. Obviously, a Surveyor who is not conscientious could calculate what the closing angle at the starting point ought to be, and then when he gets there, instead of writing down the angle which he actually observes, and which would disclose his carelessness, might write down a different figure within the reasonable margin of error and so make it appear that the traversing has been correctly done. To avoid this, it should be the rule that the Head Surveyor should go and read the last angle of the traverse himself: and also see the last leg measured and keep the length undisclosed to the computor till the traverse table is on the point of completion. Defective centering of the Theodolite over its station, and careless bisection of marks, often through not keeping them perpendicular, are the chief causes of angular

error. On a leg of one furlong, 220 yards, an error of only one inch causes an error of nearly half a minute (26″) in the angle.

21. However many sides a rectilineal figure has, when n = the number of sides the sum of its exterior angles = (n + 2) 180° and of its interior angles (n − 2) 180°. Upon this formula we can determine the correct closing of the angles. Let us now proceed to the final process of plotting the traverse on the map.

22. Let us take a sheet of mapping paper (obtainable from the Map Record and Issue Office, Calcutta or the Photozinco Office, Poona) ruled in squares of 1 inch each way with lines which we will call latitude and longitude (L L) lines (the text-book terms are latitude and *departure*, but there seems to be no sufficient reason for having a special nomenclature, and latitude and longitude are much better understood). The latitude lines run east and west, and mark the intervals north and south of any fixed point, while the longitude lines run north and south and indicate the distances east or west. We will take a point O on a central meridian for the origin or zero point, and mark against each of the longitude lines the number of feet which separate it from the origin. Likewise the latitude line through O will be taken as zero, and the distances north and south of O are similarly marked every 200 feet since we are going to make our Traverse map on the scale of 200 ft. to the inch. We now place A upon the zero point; it does not matter where we begin, but it is convenient* that the traverse should begin from some point centrally situated on the extreme north, south, east or west side of the city. Having placed A at zero or the origin, we may perhaps desire hereafter to know how all these points on the map are related to the geographical lines of latitude and longitude. In order to determine this, we have only to find the relation of one of the points on our map to those parallels and we can then write down the correct north latitude and longitude east of Greenwich for every one of our LL lines. Having placed A at the origin we shall call all distances upon the right or all movements towards the right of A Eastings or East co-ordinates and all distances left of A, West co-ordinates; all below or downwards from A will be South, and all upwards will be North. From A there runs a line AB making a known angle (azimuth) with the magnetic north, which is the meridian O. The problem is to compute the exact distance east and south of A at which B will fall.

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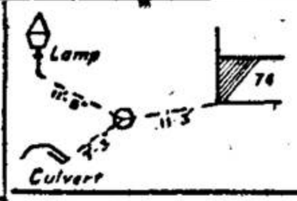
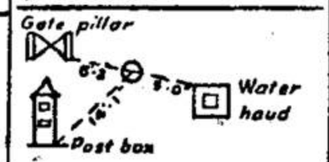
* Unless we can do better still by taking a G. T. S. station or a point at a known distance and bearing from such a station.

FORM OF TRAVERSE BOOK.

Calculation of the Elementary Traverse.

Station and Leg. 1	Tie-lines or Kaune (all strictly as looking to the North). 2	Interior angle with last leg. Observed. 3	± 4	Corrected. 5	Azimuth or North angle of the leg. 6	Reduced to quadrant Angle. 7	Length of leg (if calculated place in brackets). 8	Absolute co-ordinates. 9 N.	S.	E.	W.	Progressive from origin (with corrections in red ink). 10 N.	S.	E.	W.
					*Traverse*	*No. 28.*									
B (AB)					135° (observed)	E-S 45°	368′ 6″		260·5	260·5			260·5	260·5	
C (BC)		62° 10′	—½	62° 9½′	252° 50½′	S-W 72° 50½′	(512′)		151·1		489·2		411·7 —1		228·7
A (CA)		43° 47′	—½′	43° 46½′	(389° 4′) 29° 4′	N-E 29° 4′	471′	411·7 —1		228·7		0		0	
B (AB)		74° 4½′	—½′	74° 4′				411·7	411·6	489·2	489·2				
	Closing Totals	180°, 1½′	—1½′	180° 0′			Difference	—·1 411·6		Nil	Nil				

N.B.—In actual work the stations in column 1 will be numbered and not described by letters.

In this method, the angles in column 4 are corrected *before* the azimuth is calculated; thus the corrections do not entail corrections in the co-ordinates.

To calculate North Angle—or 'Bearing'

To the angle obtained at last station (if any) *add* (180°—the observed interior angle), always going round in same direction, either clockwise or against the clock.

e.g., for AB, observed North Angle 135°

for BC, *add* to 135° ... 180°
—62° 9½′
117° 50½′ = 252° 50½′

for CA, *add* to 252° 50½ ... 180°
—43° 46½′
136° 13½′ = 389° 4′

23. Any line drawn at any angle to any other line can be split up into two co-ordinates, one along the other line and the other at rightangles thereto. In Fig. III the line AB is at an angle A to the line AX and it can be, so to speak, split up or distributed into the distance AP along the ordinate AX and the distance PB at rightangles to it, which brings us to the end-point B of the line AB. Now the triangle APB is a rightangled triangle and the line AB is called the base or hypotenuse, and the ratio which the side AP has to the base $(\frac{AP}{AB})$ is called the cosine, and the ratio of the line PB to the base $(\frac{PB}{AB})$ is called the sine. The abbreviations for these ratios are cos. and sin. and when we say cos. A or sin. A we mean the ratio which, when the angle is A, these two co-ordinates respectively bear to the base So long as the angle is unchanged, these ratios are obviously always the same, whatever the length of the base may be. It now, therefore, will be understood what we mean when we say that the distance AB in the direction of the leg A can be split into a distance along AP which is AB cos. A and a perpendicular PB which is AB sin A.

24. Now let us consider it in rather more elaboration. Let us draw in Fig. IV the meridian N-S and the latitude W-E representing the co-ordinates North South, East and West. The first quadrant going round with the clock is from N to E; the next is from E to S; the next S to W; and the last W to N. Now we can call these the North-East, South-East, South-West and North-West quadrants; or N-E, S-E, S-W, N-W. Let us suppose that the line OP revolves the whole way round like the hand of a clock from ON right round and back to ON again, passing through every position in all four quadrants. Each minute as it moves away from 12 o'clock, *i.e.* ON, it develops an increasing angle from ON. In the N-E quadrant, this angle cannot exceed 90° until it reaches 3 o'clock when it is exactly a rightangle, and here the line OP when split into co-ordinates will give a distance along OE, but no perpendicular on either side; at this point the perpendicular disappears. After crossing the line OE, the perpendicular again appears, but on the *other side*, and speaking with respect to the point O it is a movement southwards and not northwards. Consider the line OP′ at about 5 o'clock. Here the east and south co-ordinates are quite clear, but they are not now obtained from the sine and cosine of the whole angle NOP′, but only that part of it represented by EOP′ need be considered. The rightangle may be thrown out. Similarly, when we get to 8 o'clock, the two rightangles on the eastern half of the clock may be thrown out, and we may consider only the angle SOP″. To cut this account short, we will now summarise the result of the examination of the above quadrant in the following table:—

Table of Quadrants.

North Angle.	Quadrant and Reduced Angle.		Co ordinates an i Functions from which found.			
			N.	S.	E.	W.
0° to 90°	N. E.	0° to 45°	Cos. A		Sin. A	
		45° to 90°	Sin. (90°—A)		Cos. (90°—A)	
90° to 180°	S. E.	0° to 45°		Sin. A	Cos. A	
		45° to 90°		Cos. (90°—A)	Sin. (90°—A)	
180° to 270°	S. W.	0° to 45°		Cos. A		Sin. A
		45° to 90°		Sin. (90°—A)		Cos (90°—A)
270° to 360°	N. W.	0° to 45°	Sin. A			Cos. A
		45° to 90°	Cos. (90°—A)			Sin. (90°—A)

Above 360°, subtract 360° as many times as possible, and then when the remainder is less than 360°, locate the quadrant from the above table.

25. It will be seen that as we pass from quadrant to quadrant, the ratio or function which gives the ordinate and the perpendicular changes. Sometimes it is the sine sometimes it is the cosine. But with the assistance of the table just given we can turn to any table of trigonometrical functions such as Shortrede (1865) or Boileau or numerous more modern tables (J. Pryde: W. and R Chambers 4s. 6d.) and find the exact value of the function. But in such tables, we shall find another difficulty that ordinarily the sines and cosines are not given beyond 45°. The reason is that after passing 45° the sines and cosines of the angles from 45° to 90° are exactly the same as the cosines and the sines of the complementary angles from 0° to 45° and the repetition of them is unnecessary. (Shortrede repeats them all up to 360°). When, therefore, we want the cosine of an angle between 45° and 90° we subtract that angle from 90° and look up the sine of that angle, or in other words cos. A=sin. (90°—A), and sin. A=cos. (90°—A). Now we shall find no difficulty in working out all the co-ordinates with a table which gives us the functions up to 45° only, never mind what quadrant the angle falls in.

26. In order to ascertain what angle each leg of the traverse makes with the north, the following is the procedure. For the first leg we observe with the theodolite the angle between the leg and the compass direction (for Magnetic North), or the Pole Star when on the meridian,* (for astronomical North). Thereafter, working round our traverse from left to right as the clock goes, and observing each fresh interior angle, we work according to this rule:—To the north angle obtained at the last station add the difference between 180° and the newly-observed interior angle. Now, if the newly-observed interior angle is greater than 180° (*i.e.*, if our traverse instead of bending in on the same circuit as we started upon bends, as it were, out again), then the difference between 180° and this angle is a negative difference and has to be subtracted instead of added. To make all this perfectly clear, let us now work out the north angles of the very simple traverse in Fig. I, tabulated in cols. 5 and 6 of the Traverse Sheet on p. 9; the north-angle calculations have there been given in a footnote.

27. We now have everything that we want for plotting our traverse. We know that starting at A, a leg 368 ft. 6 in. long runs at an angle of 135° from the north. This is 45° in the S-E quadrant, and therefore, we know from the table that 368·5 (cos. 45°) will give us the easting and 368·5 (sin 45°) will give us the southing, and having ascertained these quantities which are each 260·57 (since sin. 45°=cos. 45°) we plot off with a scale the distances along the east latitude line and the south meridian line, and find that the point B falls at the spot marked in Fig. I. Then at B we know that the leg BC makes an angle of 252° 50½′ with the North, *i.e.*, (deducting 180°) 72° 50½′ in the S-W quadrant, and the length of the leg BC is 512 ft. Also 90°—72° 50½′ is 17° 9½′. Therefore the co-ordinates starting from B are 512 sin 17° 9½′ South and 512 cos. 17° 9½′ West: which are 151·1 and 489·2, respectively. In all traverse work at least the first place of decimals of a foot must be retained.

28. But if we now plot these from the position of B, already plotted, if we have made a little tiny error in plotting B, we shall carry on the same error in the plotting of C. Therefore, we do not do this. But having obtained the absolute co-ordinates of C from the point B we combine them with co-ordinates of B from O. We find that from O to B there is a distance south of 260·5 and from B to C a further distance south of 151·1. We add these two together and then we scale off the distance 411·6 south along the meridian *from O*, so that if we made a little mistake in pricking the position of B, this *entirely disappears* and does not in any way affect the pricking of C. Then as to the east and west longitudes, from O to B took us 260·5 east, but from B to C takes us back again 489·2 west. Subtracting these, we find the net result is a distance 228·7 west of O. Then again, we plot from the meridian O along the latitude-parallel, and so get the position for C as plotted in the diagram. Then we repeat the process for CA.

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* i.e., from August to February when Cassiopeia is above Polaris, a little to the left: and the *middle star of the 'handle' of Ursa Major is exactly below Polaris:* and the 'pointers' are at about 4-30 o'clock; as also (in the other half of the year) when these conditions are upside down. When using a theodolite in the dark, a light must be held near the object glass to illuminate the cross-wires.

Here the north angle is originally 389°4′. But throwing out the four rightangles, the real angle is 29°4′ which is in the N-E quadrant, as indeed the diagram shows us, and the absolute co-ordinates are found to be by calculation north 411·7 and east 228·7. The progressive co-ordinates are a certain distance northwards and a certain distance eastwards, both of which have to be subtracted from the previous south and west co-ordinates of C. When we perform this subtraction we find that the progressive co-ordinates of O are practically nothing at all. In fact, the east and west co-ordinate has completely disappeared, and there is only a fraction (·1 of a foot) left for the north co-ordinate. This of course does not mean that A has moved its position, but it means that in calculating several quantities rejecting small decimals we have gone a trifle wrong. Now if we took the whole of this difference right off the co-ordinates of A, it would not be quite fair, because some portion of the difference has no doubt accumulated in the other co-ordinates. Therefore, we do the same as before in the case of the angles, and we make little adjustments (proportionate to the length of each co-ordinate) over the co-ordinates of B and C as well as A in order to get an absolute agreement and reduction of the co-ordinates of A to O. Here also this adjustment must be within the reasonable limits of admissible error. If we find that they work out to a difference of 10 or 20 feet, then it is clear that it is not merely a case of small fractional calculations, but of some big blunder which must be found out before the traverse can be said to "close." The permissible limit is 1 in 1,000 ft. of the totals of the latitudes and longitudes; careful work would easily fall within 1 in 2,000.

29. It will now be understood that in this system of traversing we can obtain the progressive co-ordinates of each point before we actually begin to plot them on paper, and having obtained them in a calculation book we can then plot them (or any one or any 20 of them) on any scale that may be required. Suppose first we plot them in a general map of 200 feet to the inch. We take paper ruled with LL lines at distances of 1 inch apart and we write O, 200, 400, 600 at the end of each line starting from the origin, just as the degrees and minutes of latitude and longitude are written upon geographical maps and for exactly the same reason. If then we are afterwards required to plot some portion of these traverses on a scale of 20 feet to the inch, we should not take the plotted map of 200 feet and enlarge it to ten times its original size, but we should take a fresh sheet of ruled paper and mark the LL lines O, 20, 40, 60, and so on, and then plot the traverse stations *direct from the calculation book*, and, therefore, there would be no error in the plotting which could be attributed to carelessness in the 200 feet plotting or in copying therefrom. Therefore, the calculation book, giving the particulars of our traversing and the final co-ordinates, is a most important document, and when it has been once prepared it must be copied and the copy must be carefully preserved *in a different place*, such as the District Record Room, and not the City Survey Office.

30. We are now able to deal with a few details. We have seen that it is necessary that we should see each station from its neighbours, and, therefore, we take the traverses across open ground, and preferably along established roads. It is also desirable that we should be able to measure from A to B and from B to C and so on. But sometimes although we can see still there are obstacles to measurements such as water, swamps, dense vegetation and prickly pear in hollows, or the ground may be so steeply sloping that we cannot measure straight along its surface in the ordinary way. The old practice for dealing with such obstacles was to evade them and make several more legs in order to get round; but obviously the more legs and the more angles, the more work and the more error. Also there is a method of getting exact distances without measuring along the ground between the points. Let us suppose A, B and C (Fig. V) are stations of which it is possible to see from B to C, but not possible to measure. Then choose a fourth point X which need not be demarcated, but may be simply a flag temporarily put up, or the gable of a house, or any other point which is visible from A and B and C. Then in addition to observing the interior angles of the traverse at A, B and C we should also observe and record the angles XAB, ABX (XBC can be obtained by

subtraction) and BCX. Then, since we have measured AB we can calculate the length BX from the trigonometrical tables, $\frac{AB}{\text{Sin. AXB}} = \frac{XB}{\text{Sin. XAB}}$ ∴ log. AB + log sin. XAB − log sin. AXB = log. XB, and then knowing the length BX we can calculate the length BC from the same tables (indeed we can use the log. XB already ascertained, without converting it) and then having ascertained the length BC we can work out the traverse and co-ordinates as before. When ground slopes considerably, an old practice was to get the horizontal distance roughly by holding the chain or tape as nearly horizontal as could be guessed, and then dropping a plumb line perpendicular or a stone from the end, and thus measuring the ground in steps as in Fig. VI. But this was only possible when the slope was moderate, and even then it was a crude and inexact method. Another way is to measure along the ground up or down the slope, stretching the tape as straight as it will go. When the slope is unbroken and continuous this is easy, but when it is variable it is practically impossible. If we can measure the crude distance up the slope BC and we want to get the true horizontal distance BC′, this can be done by setting up the Theodolite at B and fixing the telescope upon C, and then observing by means of the vertical arc how many degrees we have to lower the telescope or raise it, as the case may be, in order to get it horizontal by the spirit level. Suppose this angle to be A, then we have already shown that the length BC is BC cos. A. When the slope is very slight, this quantity is so near to 1 as not to be worth calculating, but when the slope exceeds 5° and continues for a considerable distance, we should use the formula. But when the slope is so variable (Fig. VI) that the crude distance BC could not be accurately measured, then better go back to the method described in the last paragraph and obtain the distance by calculation and not by any sort of measurement between B and C. We must remember that with the Theodolite the angles are in no way affected by the fact that one station is higher or lower than another. The effect of the spherical surface of the earth is too small to notice within the limits of a City.

31. We must remember that all maps must give the measurements in a true horizontal plane. Rome has seven hills but the distance from one side to the other of the city of Rome must not be mapped by measuring up and down each hill. If we did this in the Ratnagiri District, we should make the length of the District so great that we could not get it into the map of the world, it would be about 50 miles too long. In streets that are built like flights of steps, as in Nasik, or Naples, this precaution is most necessary.

32. The maintenance of the C. T. S. involves watching over and preserving this traverse framework. If all the stones indicating the angular points of the traverse are pulled up or are never put in the ground and if the buildings from which the distances of these stations are recorded are pulled down and re-built differently, it would theoretically be possible to relay the traverse, but only by laboriously reconstructing it from the recorded angles and leg lengths, and obviously errors of several feet would accumulate unavoidably. An error of 6 inches is most important in a C. T. S. frame work. We must, therefore, preserve the stones which mark the stations. The disappearance of one here and there would not matter much (*see* para. 15); it would give a little work to re-fix the position from the neighbouring stations. The removal of several stones in sequence would give a great deal more work. It is far easier to place the stones and preserve them. Moreover, it is also obvious that it is essential that the stone should be put in the ground first before the angular measurements and leg lengths are actually taken. If not, the measurements and observations may be taken from one point, while the stone as put into the ground by a contractor and coolies may very well be 1½ or 2 feet distant from that point it was intended to mark. All our old City Surveys erred in using a prodigious number of stations, at the corner of almost every street and gulley, and then in not demarcating them on the ground or at any rate not all of them, but leaving only a record of the distance of the station from the surrounding points which are technically called tie-lines, or in vernacular, 'Kauns' measurements. Godhra was surveyed in 1908-09: the first station was fixed by tie-lines from a tree, a lamp-post, and the boundary stone of a field. In 1916 we went to relay it, but found the tree had died and vanished, and the lamp post had been removed, and the field boundary mark was missing! Therefore, let

us lay down these canons:—(*a*) The stones used must be durable and not merely soft friable sandstone (in Dharwar we often find the stones, but so much worn away that the Theodolite cross cut cannot be found). (*b*) They must be put in the ground before the observations are taken. (*c*) There must not be too many. (*d*) Each must be visible from its neighbour forward and backward, and the distance between them must be directly and carefully measured and reduced to the horizontal, but when obstacles or difficult slopes make this undesirable, then rather than multiply stations unduly, the distance may be calculated. Iron pegs are not desirable; they cannot possibly last 100 years in a street, and they are more likely to be stolen. The positions chosen for the stations should not be in the centre of the road way if it can possibly be avoided, since they will be dug up or moved in road repairs. In a few places it may be impossible to avoid this, but usually the side of the road or open space least likely to be disturbed should be chosen. The Municipal Engineer or whoever has charge and control of road repair works should know where these stations are, and be supplied with *maps which show them*, and the Surveyor in charge of the C. T. S. should go and see, when road repairs are going on, that proper respect is paid to the stations: likewise when drainage or water works are in progress. In Bombay City carelessness has resulted in the removal even of principal G. T. S. stations, the restoration of which is most expensive. Sometimes stations can be cut on solid rock outcropping from the ground, *e.g.*, at Nasik on the river banks.

33. Errors in traversing should never exceed 1 in 1,000. In house details we need not be quite so accurate. We require to be quite certain about a distance of 6 inches, but smaller distances would be incapable of precise determination. But in the traverse work we must not allow our base line to be so much as even 2 inches out of the truth. The equipment of a traverse surveyor should include—

tapes or link chains, good and often tested,

tripod stands for holding surveying flags exactly vertically erect over his stations,

iron rods and coloured flags to indicate stations,

a string 300 or 400 feet long for occasional use in reaching over slopes or filthy places,

scale and offset of great accuracy, divided according to the scale he is using (scales with 20 divisions have sometimes been used when surveying on the scale of 33 feet to the inch),

a theodolite and the usual calculation forms and tables. Rickety Theodolite stands must not be used.

34. Some Theodolite workers are better than others in their field work, and some are better and quicker at the calculation and plotting. It is better to assign the office work of calculation, computing, and plotting the stations to one man, while two or three surveyors prepare the outdoor papers which take considerably longer time. This has the further advantage that if the traverse is found not to close or to contain palpable mistakes in angles, the independent computor will usually report it, whereas when the surveyor does his own computing, he will be tempted to make his own corrections or even alter the figures to conceal the fact that he has made mistakes in the field. For the office work good mapping paper properly ruled in squares and a large mapping board with all the accessories of a drawing office such as good long rulers and large scales must be provided. It is sad sometimes to see men trying to do mapping work with practically none of the proper accessories.

35 We can now turn back a little and describe the procedure of traversing with a better understanding. First we should ascertain the nearest station or pair of stations of the G. T. S. We can get its co-ordinates by the courtesy of the Surveyor General, and usually we can obtain copies of the field books by which useful local details of the angles immediately relevant to our city can be learnt. Usually these stations will be on a hill top, and it may not be at all convenient to measure a direct line from the station to the vicinity of the city. In such a case we may choose a base line along a road or across fields

open and level, and observe the angles to the G.-T. S. station from both ends, and thus also fix some points much nearer to the city, which can be taken into our first Great Traverse.

36. Then we can make a Great Traverse with as long legs as possible round the outside of the city, not necessarily quite outside all the buildings but upon their outskirts. The location of this traverse should be chosen so as to give the longest possible clear legs, and of course the ground must be level if possible, and if not level, the distances must be obtained by calculation rather than by the direct application of the tape. Having completed and closed the Great Traverse we should then plot it and then subdivide it into a suitable number of principal traverses which will run along main streets and divide the city into a suitable number of blocks, each surrounded by its principal traverse. It might be convenient to make all or several of these traverses meet in some central points such as O′ in the city, since the co-ordinates obtained in one traverse could then be rechecked and confirmed by those obtained in the next. In the Fig. VII these secondary traverses are drawn (*e.g.*, A. B. C. O. O′. J. K. L. M.) and it will be seen that each of them consists of some new legs (K. J. O′.) and partly of a certain section of the Great Traverse. Plainly, we have not to recalculate the Great Traverse, but taking those angles and co-ordinates as proved, we will complete our principal traverse by taking the co-ordinate of the point where it leaves the Great Traverse and proving that when the co-ordinates of the new legs are added, it closes to the known point of rejoining the Great Traverse. If we have made any adjusting corrections in the co-ordinates of that part of the Great Traverse we are using, we must *retain those corrections* in our principal Traverse and any further corrections needed must be made in the other new legs.

37. Having finished the principal traverses, we can again subdivide these into several smaller secondary traverses (like P. Q. R. S.) by taking traverse lines across them and closing them with respect to the principal traverses just in the same way as those traverses were closed on the Great Traverse. The most important and difficult problem we have to face is how small should these secondary traverses be allowed to become? In the first place, a reproduction is given of the traversing done at Dhulia and Thana [Fig. VIII (*a*) and (*b*)] where it will be seen that Theodolite stations and traverses were made, so that almost every building or block of buildings round which a traverse could possibly be run was so enclosed. The result was that in Dhulia city containing 2,145 acres there were 1,750 stations giving an average of one station to every 1¼ acres; and in Thana city containing 1,034 acres there were 892 stations giving an average of one station to every 1¼ acres. It may readily be admitted that there can be no reproach against the accuracy of such work, but there are limits, and if this minute accuracy is to be pressed we should even use our Theodolites to measure the corners of houses and take angles into their courtyards and round the gardens. The question how many traverse stations are desirable depends entirely upon what we shall find necessary in the next chapter on Detail measurement; in order to complete the subject it will be better to discuss the subject of the base lines for Detail measurement now and to show how these base lines can be constructed upon traverses and from that we shall be able to deduce how many traverses and stations we require.

Base Lines.

38. Detail measurement consists in fixing the position of a large number of points from a smaller number of base lines which base lines in turn are supported upon the traverses. The legs of a traverse are so fixed and calculated that an error of 2 inches in their position would hardly be tolerated. But it is entirely useless to attempt such minute accuracy as this in the mapping of houses and garden walls. We could not (even at the scale of 20 feet to the inch) indicate upon the map so small a distance as 3 inches, and it is, therefore, useless to attempt to obtain by measurement that which we cannot map. For all the administrative and other purposes of the City Survey, we may say, that 6 inches more or less should be the recognised limit of error, and no one should be harassed on the ground of encroachment or the like on account of a less distance than 6 inches, unless of course there was other quite clear evidence

in the shape of a recorded measurement and the position is important, as a step encroaching on a narrow road." If anyone doubts this, let him take a tape of 66 feet or 100 feet and measure the side of a considerable building. He will find that if the tape is very firmly held and stretched he will get so many feet and inches: hold it a little slackly and strained less, immediately the measurements will shrink by 2 or 3 inches. Then take another tape older or newer than the one last used and repeat the process, and it will be found that the differences will increase until one can say that over distances of 100 ft. or more it is very difficult, unless steel tapes and elaborate precautions are taken, to determine a distance within 3 inches. Our object, therefore, in Detail mapping is to fix the position of all points within about 3 inches of the absolute truth, so that a movement of 6 inches at any rate can be determined and sworn to. Our base lines, therefore, must not admit an error of more than 2 inches at the most in their mapped position.

39. The reason for closing a traverse is that at each angle and each new leg measured in the process of traversing, there are fresh errors introduced. At the first station the error will be too small to plot. At the second or even the third station it may still remain within 2 inches both as to length and as to angular arc. But after 3 or 4 stations we could not possibly claim this certainty. Of course, as stations go on some of the errors will tend to cancel one another; for instance 2 inches less, measured upon one leg may be partly cancelled by 1½ inches too much measured in the next, and 22″ to the left in one angle may be cancelled by 35″ too much to the right in the next, and so on. But we may say that if the measuring implements and the Theodolite are used with reasonable care, one ought to be able to proceed at least 2 stations without getting an error exceeding the permissible variation of 2 inches When, therefore, we already have a determined Theodolite station or other point uniquely determined in the traverse, we can safely branch off one or two stations and still claim for them sufficient accuracy, although they do not form part of a *closed* traverse. To make this clear, consider Fig. IX. From A to B is a leg of a principal or secondary traverse accurately determined and closed. A crooked lane runs from A to K and L, and the Detail measurer wants a base line from A to K and L. Now if the Theodolite Surveyor while observing the angles at A also took the angle to K and then proceeding to K which he may mark by a peg in the street also took the angle and distance to L, he can further plot this off-shoot upon his traverse map. But this might overcrowd the traverse map and it will, therefore, be better not to do that but to plot it *only upon the Detail map* frame work which we shall shortly describe. This plotting may be done either with a good protractor or still more accurately by calculating for AK its north angle which is easily known (because the orientation of A and the angles made with AK are known), and then the co-ordinates of K can be calculated and plotted. If AK is a very long line, this would be the proper course. If it is short, say not exceeding 2 inches of the Detail map scale, then the protractor would be quite accurate enough.

40. Again, suppose the said crooked line took yet another bend before it rejoined the secondary traverse. The determination of L would still not be quite sufficient, but we want to find M on another leg of the traverse. Having determined K as above, we might then proceed to M and determine the angles at M and the distance from M to L, just as we fixed the position of K.

41. When two stations A and B are precisely determined, every point along the line AB is likewise determined by its distance from A or B. We may, therefore, regard not only A and B but all the points along the line as being equivalent to traverse stations. We can plot them also with precision upon any map, because we can plot A and B, and we can scale off the distance along the joining line with any required degree of precision. Therefore, instead of making our branch base from the station A we could have equally well made it with the protractor from any point O between A and B, and had it been necessary, then to calculate the co-ordinates of OK, this also can be done; because the co-ordinates of O are immediately obtainable from the traverse book by using the length AO as a leg factor instead of the length AB which was used in the book. Such points between stations are termed 'ranging points.'

42. Again, it is quite clear that in any traverse if we can see across from A to D (Fig. IX) (another station on the traverse or even upon another traverse), then since A and D are already absolutely determined and plotted by their co-ordinates the line AD is absolutely determined and can be used just as well for a base as a leg of the traverse itself.

43. Another method is this: suppose we have a point G (Fig. IX) so situated that it can be seen from X on the leg AB and also from Y on the leg CD. Now we can determine the position of G precisely without any angular measurement and without any calculation, in this way: Measure XG and YG; then with the scale and compass from X describe an arc with the radius XG: from Y describe an arc with the radius YG: the point of intersection of the arcs exactly determines G. But this method would not be safe if XG and YG are nearly in one straight line, or even meet at an angle greater than 150°.

44 Yet another method of fixing a base line would be to join any points such as K or L or G in the above examples with one another or with any other point upon the traverse, like GZ.

45. Another method is by using the Plane Table. A Plane Table can be erected either over a Theodolite station or at any point on a traverse leg: then, having correctly oriented it, any base line can be drawn down any side street at any angle. In order at any future time to relay that base line we should require to erect the Table at the same point again and orient it in the same position, so that at any rate the adjacent Theodolite stations were correctly covered. Then the base line whether at right angles or at any other angle to the leg would be accurately obtained with the sighting rule. This method will be less accurate (in practice, because the table and sighting rules are of less delicate construction than a Theodolite, but in theory just as accurate) than the preceding but quite accurate enough for use over a short distance (say up to 100 feet). If the distance were long and still it were desired to use such a method, then some point down the base line a good distance (say 200 feet) from the place where the Table is erected should also be determined by tie-lines from suitable permanent points or demarcated. Then any possible error in the alignment of the Table can be corrected and the base line will be as accurate as a Theodolite line.

46. There are sometimes enclosed courtyards or gardens surrounded on all sides by walls and yet we wish to map their interior details and fix them upon our frame work. In a few cases we can carry a base line through a doorway, [Fig. XI (*a*)] sometimes even through a dwelling house when the doors can be opened to give us a clear view right through. [In Bombay City it was sometimes necessary to fix lines through the windows of houses. These methods are plainly undesirable (if avoidable), because the building up or alteration of the windows blocks the base line and then we lose the means of proving any point determined by that base line.] A better method of fixing a point inside an enclosure is to use a lofty rod of any material so long as it is perfectly straight and can be fixed or held perfectly upright or its upper end can be fixed vertically over the required spot with the aid of a string and plummet attached to its upper extremity, Fig. X. Having fixed up any such rod or mast in the courtyard in a place where it is visible from at least two points P, Q outside the courtyard which have been accurately determined, such as points on the traverse leg or upon another base line, then determine the position of the rod O [Fig. XI (*b*)] with a Plane Table, and then having so determined it, erect the Table on that spot O and align it by means of the same or another rod similarly set up over one of the Theodolite stations or the points P, Q on the traverse leg where the Table was last set up. Then the whole of the interior of the courtyard or other enclosure can be accurately mapped.

47. Another possible method of taking branch base lines would be right-angled off-sets taken with a cross staff or optical square, but these instruments are not accurate enough for long distances, and though they may be used sometimes in fixing single points from the base line, they should not be used for fixing the base line itself. The cross staff unless it has a tripod stand is most unsuitable or use in metalled or paved streets.

48. We now have a number of methods: (1) P. Table intersections; (2) single P.T. rays (with or without Tie-lines); (3) arc intersections from 2 known points; (4) junction of two visible known points; and (5) short unclosed branch traverses: by which base lines can be built upon the traverse frame work and of course the traverse leg itself is a base line of the highest quality and (6) can sometimes be prolonged for such uses [*see* Fig. VIII (*b*)]. The object of the City Survey is to get a base line within reasonable reach of every point which is to be mapped. Consequently, the traverse Surveyor will bring the traverse work down to sufficient proximity to each block of the city to enable the requisite base lines to be constructed; but he will not add one more station or leg or make one more traverse circuit than is absolutely necessary for this purpose. Knowing the various ways in which base lines can be developed from his frame work, he will refuse entirely to carry his traversing along every street and up every gulley and round every corner, as has been far too frequently the past practice (*see* Fig. VIII). It is impossible to lay down more definite rules than this, but plainly the traverse Surveyors require a complete knowledge of the methods by which bases can be obtained and judgment in fixing their work accordingly.

It will be seen from Fig. VIII (*a*) and (*b*) of Dhulia and Thana that when we do away with a large number of stations, it is quite true that in order to lay a particular base line we have one or two more operations to perform: we have to put up a mark over the traverse stations and then we have to measure off the point from which the base line branches off perhaps more than one such point. This is undoubtedly more work than there would be if we fixed a station and buried a stone at every corner, as under the old system. But we have to remember that to provide so many stones and to inspect and preserve them all and to replace auxiliary marks if the stones are buried (*see* para. 32) would entail a very much greater initial cost and a much greater recurring cost of maintenance. And even then there would be a risk that through the multiplication of stations many would be lost through inability to watch over them all. All these considerations have been weighed in judging that a limited number of frame-work stations, rigorously and carefully preserved, is the best system.

49. The position and number of Theodolite stations should be chosen by the Head Surveyor, whitewashing a cross or circle on the ground at the points which he selects. The Theodolite Surveyor will take very much longer to have the stations actually demarcated and observed, but the choosing of positions occupies a few minutes only. In making this choice the Head Surveyor must judge between the two principles (1) that the number of stations must be made as small as possible; (2) that the number of stations must be sufficient to give the bases required for the Detail measurement; (3) all stations must be visible from their neighbours along ground which is likely to remain permanently free from obstructions to this visibility. When these stations have all been chosen the angles and legs must be measured and recorded in a rough note book, with a rough, but not utterly disproportionate, sketch to guide the computer and the proving of the angles and closing of the co-ordinates proved in a fair traverse book in the form at page 9. Then these must all be plotted first on a map with LL lines at 200 feet to the inch, and the number of each station with the leg lengths and angles must be entered on the map (*see* S. E quadrant in Fig. VII) and in the records; and the whole must be so indexed that any station and its calculations can be found in a moment. We must also measure the distance of each station from adjacent corners of houses or bridges or other permanent or reasonably durable marks. Ordinary wooden lamp posts or huts are not substantial enough. A bad habit has been noticed of choosing the stones at the base of Municipal lamps or even guard-stones at the sides of roads as Theodolite stations. This must not be allowed, because if the Municipality or the Public Works Department widen or alter the road or the lighting system, the station would be removed, and we should have to replace it at much labor and expense. Where there is a drainage or water supply system, the positions of the pipes in the ground cannot be frequently altered, and therefore the man-holes giving access to the system may be regarded as fairly fixed. In the Poona City Survey, these man-holes have been adopted as Theodolite stations. It is very unlikely that the Municipality

would, at any time, allow buildings to be erected across these man-holes, nor would they move the pipe system lightly. It is, however, quite conceivable that in a century or two an entirely new and revised system might be introduced and all the old man-holes cancelled. In that contingency we should then have cause to regret the choice of these stations and we should have to replace them by stones laboriously recalculated and buried as nearly as possible in the position occupied by the centre of the man-hole. In our traverse book the tie-lines and (when the station is not the usual buried stone), its nature should be clearly shown. When all these stations have been plotted from their co-ordinates on the 200 feet map we then have a complete frame work which shows no houses or properties, but only our stations. It is more permanent and preservable than any building or other detail in the city. Moreover, as already pointed out, any portion of this frame work whether a whole traverse or a part of one can be replotted on any other scale larger or smaller than 200 feet, not by copying or enlarging from the traverse map but direct from the recorded co-ordinates.

When the traverse field book is finished and closed correctly, it is easy to see how the general traverse map like Fig. VII and the detailed measurers' frame work will be plotted. Each point is placed in its proper square by its co-ordinates. But in plotting the detailed sheets one leg will often fall partly in one sheet, partly in another. We want to determine at what point it crosses the boundary of sheet I and enters sheet II, *see* Fig. XXVI. Suppose A and B are the ends of the leg, A being in sheet I and B in sheet II. The meridian of 800 divides sheet I from sheet II. We know the co-ordinates, that is, the northings and eastings of each point. It is wise to make a rough pencil sketch to guard against inadvertent blunders. We then subtract or add these co-ordinates in the manner described in para. 80, to get the two sides of the right-angled triangle of which AB is the hypotenuse. In the Fig. $\frac{OB}{OA}$ is the tangent of the azimuth of AB. The meridian of 800 cuts AB at X; XY=(800—east co-ordinate of A). We want to find AY. Now $\frac{AY}{XY}$ = Tan (90—OAB) or cotan OAB,

$$\therefore \log AY = \log XY + L \cot. OAB.$$

whence AY can easily be got from the Tables. If the boundary of the sheet in question had been a north or south boundary, then the co-ordinates would be used in the other order: sometimes even both boundaries might be crossed at a corner: the calculations would be quite similar and the pencil sketch would protect the computer against mistakes. He can then mark on each sheet the exact points at which the traverse leg crosses the boundary.

50. Among other duties, the Head Surveyor must test all the tapes or chains in use weekly. An old tape which stretches 3 or 4 inches, would cause error in traversing. He must also see that all the instruments are in proper condition. He must exact a fair output of work from his Surveyors. When they do the computations and fill up the final traverse book themselves, a fair output is 7 stations a day. When the calculations and office work are done for them by a computor detailed for the purpose, a fair output would be 10 stations per day. Each Surveyor will have a diary and will show the number of stations observed or whether he is engaged on some other work such as supervising the burying of stones in advance or helping in the selection of forward stations.

CHAPTER III.

Detail Mapping.

51. The detailed mapping is done upon sheets of mapping paper ruled with LL lines and of good quality, but not too thick and not cloth mounted (which makes tracing difficult). The best arrangement is to have the sheets of the same size as the Plane Table top and for this purpose the Plane Tables used in City Survey should have rather larger tops than ordinary. 30″ × 24″ will be a useful average size. The mapping paper is not to be carried in the hand and rolled and unrolled on each occasion, and never folded up, but should be pinned on the Plane Table top even when we do not intend to do any of the work by the Plane Table method. The map should be covered with a cloth when it is left standing, and not infrequently dusted with a cloth during work as much dirt falls in the ordinary street, and should be pinned down upon the board by drawing-pins placed on the vertical side of the board, and not on its face. Pins spoil both paper and table; and clamps are better, if obtainable.

Note on Squared Paper.—When moist, paper expands; when dry, it shrinks, as compared with its normal size under average conditions. Moreover rolling and unrolling, and straining on boards unevenly distorts it. Machine made paper suffers more than hand-made. All our paper for C. T. S. original maps should be of good hand-made quality (just at present owing to War conditions this is difficult to get). It ought also to be grey or buff, since this tires the eye less than white.

If ruled in exact one inch squares, it is probable that after use in the field for preparing detailed maps, the size of some squares will be increased or diminished; the longer it is kept and the more it is handled, the worse this will be. We want, therefore, to know how (1) to preserve the paper in its best condition; (2) to test its correctness; (3) to remedy distortions when discovered.

(1) By using the paper as suggested in para. 51, some benefit will ensue; better still, if we can afford aluminium clamps for holding the paper in position without pinning or straining. If the sheet is larger than the table, do not leave it flapping about, but roll the surplus up and pin a loop of tape round it at both ends. Thus it remains steady, rolled against the table's edge. As soon as detailed mapping is done keep the map in a portfolio and never in a roll or tin, &c. Caution E. O's. staff against illtreating it and as soon as E. O. has finished his tests and enquiry, the map should be traced and printed as promptly as possible.

(2) To test the exactness of the squared paper, apply a straight edge (with which each office should be equipped) to the long lines and across diagonals as shown in Fig. XXVII and see that they are perfectly in line, and that the full length of the divisions across the paper agrees with an exact standard scale. Take a compass and strike circles with the corner of any square as centre, and 5 divisions of latitude or longitude as radius. These circles should pass exactly through the corners (marked in the Fig. with arrows) where 3 × 4 and 4 × 3 co-ordinates meet, because $3^2 + 4^2 = 5^2$. Any multiple of this series such as 15, 9, 12; 20, 12, 16; will fulfil the same conditions.

(3) If we find the paper so distorted at the time when we desire to trace and print our map that we cannot trace from it directly, what can we do? The distortion over 20 divisions may amount to half a division or even more, and worse still if at some point the map has been cracked or torn. Yet within a single square the distortion is almost inappreciable, not exceeding 1/50th of the division or square. No single point inside such a square can be more than 1/100th of the square out of its proper place with reference to the boundaries of the square. Therefore, taking a new and accurately squared sheet of tracing paper, lay it over the distorted sheet, and taking care not to strain or distort the new sheet, retrace each square of the old sheet *separately*. This means, after tracing square 1 into new square 1-a, shift the tracing sheet very slightly so as

to make square 2-a fall as closely as possible on old square 2, and then trace square 2. Repeat this for each square. In this way we shall practically eliminate the distortion and can print from our new tracing.

52. The equipment of the Detail measurer will, therefore, be a Plane Table which must be in good order and rigid, and not warped, with level and alidade, and measuring tapes, one long (66 or 100 ft.) and one short of about 12 to 50 ft. for taking little offsets, &c., more quickly; a long cord or roll of twine about 300 or 400 ft. in length, (360 ft. cost one rupee at present), a dozen iron rods with small colored cloth flags on their upper ends (in some localities a larger number will be required when there is much open ground to be surveyed). Also a good pair of compasses with a scale and offset-scale, hard drawing pencils, and India rubber; also an optical square and a line with a lead plummet, and the long rod or pole required for sighting over obstacles (*see* para. 46 above). Also he may be given the same tripods for supporting flags over the stations as were allotted to the traverse Surveyors. He must also have a note book for remarks worth preserving about disputes and difficult places, and some waste paper for scribbling rough measurements and details before carrying them to the map: he may desire to take 6 or 8 offsets continuously before he plots them. The Plane Table can be accurately set up over a desired spot, such as a Theodolite station or a point upon a traverse leg, by means of four pieces of split bamboo with a fifth cross-piece like a trestle with a string and plummet tied to the cross-piece (Fig XII). The whole is about 6 or 7 ft. high. This trestle can be very rapidly placed in position so that the plummet on the string hangs exactly over the required spot and about an inch or two from the ground. As soon as it has been set in this position, the string should be shortened by about 4 ft. by looping it up without disturbing its suspension point. Then the plummet will still hang about 4 ft. from the ground vertically over the spot selected. The Plane Table can then be placed underneath this hanging plummet and got into the position required with the station exactly under the plummet which will be hanging a few inches above the Table. (The cord line and plummet is also useful in taking certain offsets in para. 56 below.) But a careful man with a good eye can get his Plane Table within an inch of the proper spot without such paraphernalia and it is not recommended as a necessary article of equipment.

52A. Now the object of the Detail Measurer is to fill in upon the traverse framework all the details in his block. The Theodolite Surveyor will have drawn on his map sheet, according to the required scale, all the traverse stations and legs which fall upon that sheet. This will be done by their co-ordinates (*see* paras. 29 and 49). The LL lines on the Detail Measurer's map will be numbered according to the distance in feet from the origin (*see* para. 29). The first step for the Detail Measurer is to fill in base lines sufficient to give him a base along every bit of street or passage-way wherever he may require to fix points. Having drawn the base lines, he will then determine the position with reference to them of every point on the map. Sometimes the Theodolite Surveyor will provide him with a few branch bases (*see* para. 39).

53. *How to fix a point.*—The Detail Measurer must be equally facile and conversant with all the methods of fixing points. He must use whichever method is most suited to the position in which he is working. The methods which are possible are these:—

(1) Determine the point upon the base line at which a perpendicular from the required point falls upon that line. Then measure the distance along the base line from its nearer end and the length of the perpendicular. Then again measure the next point in the same way by taking a further distance along the base line and another offset. When a succession of distances along the base line are so numbered, we should remember that it is better to write down not the broken individual distances of each point along the base from the last point, but the entire unbroken distance of each point from the nearer end of the line. Since the greater the distance, the less exact the measurement will become, we should never carry this progressive measurement beyond the middle point

of the base line ; but we should then go to the other end and carry on our measurements by the shorter distance from that end. Then we may as a check upon our measurements see what remaining distance is left in the middle, *see* the example in Fig. XIII (1). Rectangular offsets can be obtained either with a Cross Staff or an Optical Square, or when the offset is quite short, say less than 10 ft., by the method of holding the end of the tape firmly at the point which is being measured and revolving the tape radially until we find the shortest distance from the point to the base line. We can call these 3 methods the Cross Staff, the Optical Square, and the Radial methods. The Cross Staff is the worst, because it is heavier and more difficult to move about, and because it cannot be set up firmly in paved streets, unless elaborate tripod stands, &c., are used. The Optical Square is fairly accurate if carefully used. The Radial method is permissible only for short lengths. But all the methods depending upon a right-angle involve three elements :—(1) a distance along the base line ; (2) the length of the offset ; and (3) the observer's estimate of the exact right angle. Any method of determination which depends upon fewer elements would be safer. When the street in which such offsets are being taken is wide so that on one or other side of the base all the offsets exceed 20 or more feet, take an *auxiliary* Base Line [such as L M in Fig. XIII (1)] parallel to the main base and 20 or more feet from it : so that the offsets are all shorter by this distance.

(2) Take upon the base line two points, the distance of which from the end of the line is easily determinable, preferably taken in round figures such as lengths of 40, 60, 80 feet. Marking these points as centres, we then measure the actual distance from them to the points under observation. Then upon the map sheet we plot the position of the two fixed points on the base line, and from each of these with a compass we describe arcs for the distances of the required points ; the intersections of these arcs give for each point its correct position Fig. XIII(2). It will be seen that this method also requires for each point the measurement of two distances, but does not require the estimation of a right angle, and the fixation of the pivot points along the base line is a simple and more accurate operation than the determination of the foot of the perpendicular.

But it should be noted that it is not accurate when the point to be fixed lies close to the base line (*see* E in the figure) ; because the point of intersection of the arcs is hard to determine, and a small error in measurement of the radius makes a large error in the position of the point, *see* Fig. XIII.

Both the above methods require that the measurement should be taken on the ground and then be transferred to the paper by means of a scale and a pair of compasses, or by direct measurement with the scale. The most careful men may sometimes make slips in this operation.

The next method involves no such possibility of error, *see* Fig. XIII (3).

(3) The Plane Table can be set up at any points along the base line, or indeed at one point on the base line, and then at another point off it. From these two points with the Sighting Rule the location of all visible points can be directly mapped *without any measurement at all*, except only of the distance between the P. T. stations, *i.e.*, the use of the tape once for all the points instead of twice for every point, and practically no use of the scale and compass at all. For this reason if the Plane Table is correctly used, it is *more accurate* than the other methods, assuming the same skill and care in its use as we must assume for optical square, Cross Staff, or arc-plotting work. Where the points to be observed are not sharply defined by the corners of houses, &c., the iron rods with little colored flags upon them set in the ground at the points required are most convenient.

(4) Another method is to set up and correctly orient the Plane Table at a known point. We can then measure, from the point over which the station marker on the Table stands, the distance of any required point, and

can then draw a ray in that direction with the Sighting Rule; or when the point is very close we may even sight it with the edge of the scale and plot off with the scale the equivalent of the measured distance in that direction. In this way the interior details of narrow courtyards can be exactly obtained even where there is hardly room to set up the Plane Table at more than one point.

We may call these four methods, the Perpendicular Offset, the Arc-intersection Offset, the Two-Station Plane Table, and the One-Station Plane Table method. When carefully done, there is no practical difference in the accuracy of any of them, though, theoretically the Two-Station Plane Table method is the most accurate. As already stated, the Detail Measurer must be equally ready to use any of the four, and which one he will use depends entirely upon the conditions on the spot.

54. But besides the points which can be seen from the base line, the Surveyor will often find points which may be called *blind* points, which can only be fixed from a base line by building up another base line behind the obstacle. Now, for one or two points only this will be extravagant and too laborious. There are several ways of determining a 'blind' point and plotting it without seeing it from the base line. If it is the corner of any quadrilateral building, then if two sides have already been fixed the remaining two can be fixed by arc-intersections, and this could be done even though the sides are not exactly straight; and once the corner has been determined, intermediate details can be plotted in without any difficulty, *see* Fig. XIV. Here the blind points E, F invisible from the base line having been fixed by intersection from the points L, M, and from L, F. [*see* para. 53 (2) above], the minor bends on the invisible side LE can be plotted in with the scale and offset scale. When there are a number of blind points behind a whole row of houses, then of course it is best to take a base line or at any rate to fix Plane Table positions round there and plot the leading corners, the minor bends being plotted in with the offset-scale.

55. We must be careful however not to assume that the angles at the corner of every building are right angles. When the length of the sides is very small they may be taken to be right angles and plotted accordingly. But many buildings in cities are not at all rectangular. It might not seriously matter so far as the mapping of the individual house is concerned, but it would make a lot of difference if we were misled into plotting other buildings or streets upon the position obtained by assuming that the house is rectangular. In the Fig. XV, if the house had been rectangular we should have drawn its sides as shown in dots A, B, C, E and then the little lane behind the house would have been likely to be shown with wrong dimensions.

56. One caution is necessary in all offset measurements to points of buildings, &c. Walls are not always vertical and it is a question what particular point we should take. Three illustrations are given in Fig. XVI. In the first we should be justified in measuring from the exact foot of the wall; in the second the projection at the foot of the wall is very likely only rubbish and debris, so that the measurement ought to be taken from point A; while in the third again it would seem right to take it from the point vertically below the main face of the wall. No regard is ever had in City Survey to upper storeys or projecting balconies or eaves; the building is plotted as it springs from the ground. If land beyond the base of the wall belongs to the house owner, this will be mapped as open space; but the aerial projections are not evidence of such ownership. Even steps which project from a building are not marked as built-over, but open property. If the land on which they stand is really the property of the house owner, then include them in the boundary line of the property; but if they are only an easement, exclude them from the boundary line. Whenever we take a measurement from the top of a flight of steps or from a point above ground level in a wall, or across a ditch or gutter, or at a place where the ground slopes, take it in the manner exhibited in Fig XVI (II). The plummet line held in the hand over the base line is the same plummet line used for erecting vertical masts (para. 45) or for setting up the Plane Table trestle (para. 51). When an offset has to be measured along sloping ground so that a horizontal distance is required and yet the distance is not considerable enough

to make it worth while calculating the cosine by the tables (*see* para. 30) the same method can be adopted, holding the tape as horizontal as possible in long or short legs according to the degree of the slope, *see* Fig. VI.

57. The next question that requires consideration is what is a single property and what are we to show upon our maps. Clearly, the house and its own compound is one property, but two different houses having one common or joint compound constitute three properties. Within the limits of each single property we must distinguish what is built over and what is open. This should be determined upon the 'light-and-air' principle. If the ground is paved with stone but still open to the sky, it is not 'built-over'; while if the ground is in its natural state, but is covered completely by a roof, it is built over. An open verandah with the upper storey covering it is 'built-over' but a platform or ota projecting beyond the line of the roof or upper storey is open and not built-over. In the District Municipal Act, III of 1901, Sec. 3 (7) defines buildings as including doorstep and fixed platform, but this is for other objects. The building should of course be reasonably permanent. A wedding Mandap of cloth or thatch is certainly not a built-over area; neither is a temporary sun screen put up over a street stall or to shelter an animal from the sun, if it is not walled round. But where temporary ends and permanent begins is a matter as to which no rule could possibly be laid down; the Surveyor must look at the structure and form his own opinion after making reasonable enquiry of the occupant. It may, perhaps, be said that the general tendency in Indian cities is that when a temporary structure is put up, it is soon converted into a more substantial one, and this in turn soon becomes practically permanent until some complete change of fortune compels the owner to abandon it, or it becomes destroyed by white-ants or decay and he has no means to re-erect it. Therefore, the tendency should be to regard structures as permanent when there is real room for doubt. Huts present peculiar difficulty. Are we to show them as permanent buildings or not? They are usually so transient and liable at any time to be removed or reconstructed that it seems waste of time to map them with the same accuracy as solid structures. Where a plot of ground whether public or privately owned is devoted to huts, the occupants of which are not the owners of the land but pay a small rent and simply squat there on sufferance, then it seems better to treat the whole plot of land as one property and simply indicate the huts by dotted squares showing the number of huts and their approximate position, but not measured in detail. The word "huts" might be printed across the whole space, and one Sanad given to the owner for the land. Where, however, the hut owner is also the owner of the land or its long term lessee, each such hut plot must be mapped and a Sanad separately given, and the dimensions of the hut correctly shown. The Municipality require to know the location of these huts for sanitary control, but usually from their very nature they are not intended to be permanent and would be removed at once, if it were desired to erect more substantial buildings.

58. The law requires us to give a Sanad for each "building site separately held:" that is not the same thing as separately owned. One man may own the sites of 5 or 6 houses and he may live in one house himself and let the others to other people. Clearly here each of the houses is separately held (because a 'holder' includes a tenant), and 5 Sanads will be issued. They will however all be in the name of the owner (*see* para. 138) and issued to him. Therefore, the Surveyor must map each house separately. But this applies to the ground floor only. If the owner lives in the ground floor and has sold or leased in perpetuity the upper floors, although the upper structures are different properties (for purposes of Municipal taxation, perhaps) they are not *building sites*, and we do not map the city in vertical section but horizontally, and therefore we map the ground floor only. But *see* p. 59. Between houses separately held there often are passages or alleys or streets through which the occupants of the houses must pass, and which must be open for the public to go in and out in order to call at the houses. For instance the postman or the policeman or suppliers of domestic provisions must be permitted to approach the house by these ways. Although such passages may be originally or at present owned by the owner of the houses still they are "private streets" and the Municipality and the occupants of the houses can intervene and veto any attempt to block up or build over

these passages which under the Easements Act soon become 'public'. Such private streets, however large or however small, should not be included as part of the properties, but mapped as part of the streets, but the fact that it does not appear to be public street will be indicated by the Surveyor drawing a (dotted) line across the junction with the public street. Of course, the final decision about such matters is for the Enquiry Officer; if the Surveyor makes a mistake, that will afterwards be set right. But he should not make mistakes wilfully or carelessly. In each property the built-over portion is indicated by rough hatching with the pencil or pen. In the maps traced for printing, this will be done more neatly. The original maps will just indicate the building sufficiently to prevent the tracer making mistakes. When the built-over portion is not the whole property the boundary between built and unbuilt is shown by a light line, while the boundary of the property itself is a heavy line. When a property is enclosed by a wall if it is a house, it is simply shown as built-over, but if the enclosure is an open space like a garden, then a second line is drawn less heavily inside the boundary. Fences or hedges are marked by a single crossed line. The boundary for legal purposes of the City Survey is the exterior face of the enclosing wall or hedge of the house, garden, &c. Where there is no wall but only perhaps a fence or a ridge, or nothing at all, to determine the boundary of an open space a single firm line will be drawn. Between houses the wall is sometimes the property of one house, sometimes common to both, and sometimes there are two walls touching one another, each belonging to its own house. These are shown in Fig. XVII.

59. These signs are not made to show the thickness of the wall. A wall 3 feet thick would be a very considerable width on a 25 feet map, but the double lines are indications of ownership and signalise that there is a wall. Doors which open on to public or private streets or jointly-owned spaces are evidence of a right, and must be shown. Where a door opens only on to land privately owned by the householder as along the line P Q in Fig. XVII there is no particular right, and he does not claim easements against himself; therefore, such doors are not shown. Nor are any internal doors or the divisions of the house into rooms, nor do we show any windows or balconies. It is true that these constitute easements, but they are not easements *upon the ground level*, and they are not ordinarily shown in City Survey. But it is entirely unnecessary to measure the precise position of the door in the wall or its width. Much labour might be so wasted. All that we require to know is that a door does give access to the house on that side. Therefore; the Surveyor should measure the full length of the side of the house and plot that, and then should place the sign indicating a door at its approximate position in the side by eye-measurement. When the whole side or a great part of the side of the house is an open, but roofed over, verandah or platform from which access is had to the street or open space at almost any point, the whole side of the house will be marked with the symbol for a door; but when the side consists of a platform or 'otla' open to the sky, it is sufficient to show that open space, because the house owner can plainly have access to the open space from his house, and from the open space included in this property it is obvious that there must be further access to the next open space beyond if it is not walled in. We follow the same principles in the case of steps, though here we shall indicate by measurement the extent to which the steps project into the street, as this is often an important source of dispute. Figure XVII shows houses with ordinary doors opening on to streets and on to open spaces and with open verandahs and roofed verandahs giving access to street with steps which are only easements, and steps which are privately owned and an external flight of stairs reaching to the upper floor, and houses of 1, 2, and 3 storeys (indicated by Roman numerals), and with common walls, double walls, and walls singly owned, and walled and unwalled open spaces and open spaces distinguished from built-over spaces within the same property.

60. In addition to these details, the Surveyors may be also instructed to mark wells, privies and tanks in private land, public lamp posts, water hydrants, tramways, post boxes, &c., &c., as may be necessary in each particular survey. Within the limits of a property all built-over structures will be exactly shown,

but open pavements, paths or patches of cultivation or garden and flower beds or paving around wells and the like will not be measured or mapped. But any tomb or architectural or historical remains or anything of that sort which the Surveyor notices, he should map, and if in doubt, will ask for instructions.

61. What is the Surveyor to do when he comes to a disputed space or a plot of land for which nobody can give him any information or explain how the boundaries run? It is not his duty to judge and decide disputes. But if A and B point out different boundaries, he should mark out and map the boundary as shown by each of them, and should write a side note saying "Boundary claimed by A," "Boundary claimed by B," and if he puts a mark to attract attention, it is quite certain that the E. O. will not overlook it. When he cannot decide if a street is private or not, or is a street at all, he will map it according to his judgment with a note either written in the map or in his pocket book, which will be sent in the form of a statement of doubtful points with the finished map to the E. O. indicating the nature of the doubt. If no information could be obtained at all, he must leave the space undefined, but sketch pencil dots across somewhere about where he thinks the division goes. E. O will then enquire and if he finds there is no boundary, he will either lay down some arbitrary boundary or will absorb the space in the adjacent property or open space. When he comes to the boundary which the Collector has notified as the town-site boundary under section 126, the Surveyor will mark that very plainly on his map, since his measurements will not go beyond it, except possibly for the purpose of indicating the direction in which a street or Railway or something like that continues. No properties beyond the boundary will be mapped in detail. In addition to this boundary there will also probably be the original old boundary of the Gaothan, dividing it from the fields which originally were treated as agricultural by the Revenue Survey; this boundary also will be marked wherever it is ascertainable. There are sometimes points at which it cannot with precision be determined. Here he will dot it to join across to the determined portions. If the location of the boundary has any fiscal importance, E. O. will endeavour to fix it with more precision. If several Revenue villages come within the C. T. S. area, the boundary between these villages will also be indicated by a distinctive line. Frequently this sort of boundary will be found to run right through the middle of houses. When the City Survey area unavoidably includes some agricultural lands, although the City Survey law does not apply and though no Sanads can be given, still the limits of individual holdings (which can usually be easily plotted with the Plane Table) will be shown if the block is quite small; but if it is extensive it will be best to leave it blank and mark it "Revenue Survey Area." It is very likely that such areas will in future be built over. But if so, they will probably first be laid out in proper streets and roads, the area of which becomes public road, and the boundaries of the building sites which the Collector sanctions are likely to be quite different from the crooked and irregular boundaries of agricultural plots. It is, therefore, entirely a waste of time to map such boundaries until the area has been laid out. But in those places where maps of agricultural holdings under the Record of Rights Act *have not been prepared,* here it is desirable that the City Surveyor should fill in these details, and instead of charging for Sanads, fees should be levied under Section 135-G, L. R. C., a formal order being given by the Collector to the City Surveyors to prepare the maps under that section. Even so these maps will not rank as C. T. S. maps, but the boundaries may be useful for development purposes in the absence of any *other* satisfactory cadastral map: and will probably rank as boundaries previously fixed for the purpose of Section 119, clause 2, L. R. C.

62. We cannot map the whole city in detail on a single sheet. It is, therefore, necessary to decide how to divide the sheets. There are two methods which have hitherto been followed, which may be called the 'Square' Method and the 'Traverse' Method. Let us consider them in detail with their defects.

63. By the 'Square' Method we take the 200 ft. skeleton Traverse map of the whole city, and then divide it into squares or rectangles of uniform size, making the divisions down the LL lines. The advantages of this method are that we can at once and without difficulty fix how many sheets there will be and we can

work out the most suitable size and shape. If the city is much longer North to South than East to West, then we might make the sheet 36 inches North to South and 24 inches East to West. If we find that the whole city would be contained by 5 sheets 24 inches wide, then also we could choose 4 sheets 30 inches wide. We need not be worried by the fact that the LL lines cut through important buildings or streets; and also we shall know that the gross area covered by each sheet is calculable with instantaneous facility, since the number of 1 inch squares is known. But the *disadvantage* of this method is that it adopts sheet boundaries which cut through buildings and which often go across principal streets in an awkward diagonal way. And whenever there is need of inspecting buildings near the boundary of the sheet we should be obliged to take both sheets. This difficulty would become much greater when we got close to the corner of the sheet. By trying this method in Bombay City it was sometimes found that portions of the same house came into 4 different sheets. The grave inconvenience of this is obvious.

64. The 'Traverse' Method is to take one or more whole traverses, *i.e.*, secondary traverses, and map, upon one sheet of the size adopted for the city, only so many complete traverses as would fall upon that sheet. The traverse stations and legs are drawn and form the boundary of the detail mapping. This method it will be seen does not enable one to economise in map sheets. It probably requires 50 per cent. more sheets than the Square Method, since each sheet will not be filled to its margin but will leave substantial blank spaces outside the traverses. But the chief defect is that since we are obliged to lay the legs of our traverses *down the streets*, every principal street is divided by a sheet boundary, and here too we should require two maps whenever we have to deal with any question involving the houses on both sides of the street, such as road widening, encroachments, and so on. It is true that we can meet this difficulty when we come to the tracing stage by copying the other side of the street from the other map. We may, therefore, say that there is not much to choose between the Square Method and the Traverse Method, except only in the matter of paper which after all is not very important. But since the sheets are finally to be all united into a general map, the reduction in number of sheets, and the extreme facility of joining along the LL lines is much to the advantage of the Square Method.

65. But another consideration must not be neglected. After finishing our Detail Survey we want to number the houses in the city. This numbering is for public use as well as for the mere Fiscal and Legal purposes of our Property Register. It is very desirable that the numbering should be useful for the Post Office, the Municipality, the Census, the Police, and various other interests, and for the public generally. Now for public and Postal purposes it is highly inconvenient to have the houses and shops on opposite sides of the same street differently numbered. The numbering in cities which is most popular is that which runs straight up and down streets; and when there is to be a division between one set of numbers and another the dividing line runs along the *back* of the houses rather than down the middle of the streets. Again the houses in Indian cities are frequently so arranged that out of one block of buildings several have doors opening on to one street, while the rest open on to another street, such as an inner private street. Therefore in numbering, we must follow the streets and we must carefully notice upon which street the front doors of the houses open. We shall print in our C. T. S. maps, the names of all principal streets. The numbers we shall give to the houses will run, therefore, continuously through several sheets at least. Usually we shall divide the city into sections such as the Camp, the Railway Quarter, the Fort, the Shanwar Peth, and so on, following the traditional divisions as nearly as we can. Therefore, no single map sheet (whether Square or Traverse) is at all likely to coincide with one quarter or section of the city; and the numbers, therefore, must run without reference to the individual map sheet. The best method of numbering will be when all the original sheets are finished to lay them together on the floor and first determine the boundary between, say, the Fort and the Bazaar, and draw that with blue pencil running along the backs of houses, and not down the centre of the big streets Having drawn the periphery of the Fort, we then proceed to number the houses throughout its extent in due sequence, not with a fresh number for

each street, but if there are 850 properties in the Fort area, then we start from No. 1 up to 850, so that the houses in Willingdon Street run, let us say, from 431 to 476, and then 477 is the first house in an adjacent street, and so on. We shall have a little more to say about numbering hereafter, but it is necessary to refer to the question here in order to determine the best method of dividing up the detail maps.

66. It will be seen that we have arrived at the independent conclusion that the numbering cannot and ought not strictly to follow the mapping sheets. Therefore, we can leave out of account the question of numbering in fixing our sheet boundaries. After considering the various difficulties and disadvantages, one is forced to the conclusion that the best system is a 'square' system, according to the LL lines *so modified* as to avoid almost all intersection of single properties. We then take one map sheet for one rectangle, but we allow on two sides (say East and South) a margin of 2 inches extra, *i.e.*, suppose we want to have a map 24′×30′ we should actually take 26′×32′ so that on two of the four sides there may be at least 2 inches duly ruled in squares and available beyond the strict margin of the square. Now the Detail Surveyor, when he comes near the boundary of his sheet, will find that some houses commence inside his boundary, but run beyond. On the North and West of his sheet he will *not map* such houses, but on the East and South he will, continuing them over into the 2 inch margin. Most of them will be finished off within that margin. There will be a very few which will again go beyond that: *i.e.*, on the scale of 25 ft., those intersected properties which stretch more than 50 ft. beyond the boundary of the sheet. As to these, he will take instructions whether (1) he should go still farther and complete them or (2) when only a small piece is in his sheet and the bulk is in the adjacent sheet, he should leave them to the next sheet surveyor, or (3) whether he should carry them to a suitable dividing point only. At any rate, there will be *very few houses* or properties [only those of class (3)] divided by the sheet boundary and none which are cut into 3 or 4 pieces at the corners of the sheet. It will be found that some principal streets still fall partly in one sheet and partly in another, they will be divided transversely and not longitudinally as in the Traverse Method. There is no device by which a city can be divided without some such inconvenience. There will be some instances in which it will be desirable in the printed maps to shift the boundary of the sheet 3 or 4 inches to the east or to the north or otherwise, so that the whole of an important street may fall into one sheet. When all the original sheets have been finished and before tracing begins, a scrutiny of this sort should be applied to them all in order to see whether any alteration in the boundary will give more convenient divisions. If it is found that it will be so, then the new boundary can be painted across the original sheets and (in the tracing) the revised sheet limits will be followed. It is quite easy to trace part of the final map from one original sheet and a part from another, because we always have the LL lines as an infallible guide in joining.

67. On the East and South border of sheet A (*see* Fig. XVIII) the Surveyor will, therefore, carry on and complete the few houses which run beyond the boundary. The Surveyor who is doing the adjacent sheet B will know which houses have been fully plotted in the other sheet A (because they go also beyond his boundary), and in his sheet will only do those which did not commence in sheet A but fall entirely in his own sheet like house 27 in the Fig. Throughout the sheets, the East and South boundaries take precedence over the West and North of the adjacent sheet. For further details *see* Fig. XVIII.

68. Let us next consider the question how many of his measurements or working methods should the Detail Surveyor show on his original sheets. This is intimately connected with the question of tests and area calculations, and Sanads. In order to test this work, is it essential that the actual length of each portion of the base and each offset or radius in feet and inches should be written down? Also do we require these measurements for issuing the Sanads? The old method of survey was to write down the measurements of all the sides of each house as well as the offsets separately in a rough field book, and from this rough field book subsequently to plot the map. This involved much plotting work in office and other drawbacks we need not now consider, but it enabled us

to write in the Sanads the dimensions of each side of each property. But we now propose to give as the Sanad maps portions of the printed maps cut out and affixed to the Sanad Form. Plainly this will prevent any discrepancy or error of copying, and since we shall print the scale upon the Sanad, any person who knows how to use a scale can apply it to the Sanad map and ascertain the dimensions within 6 inches. But this does not entirely satisfy illiterate or uninstructed persons, and when we are able to do so, it will be advantageous to write on the Sanad Map some of the main dimensions. If this can be done for 2 out of the 4 sides of an ordinary property it will be quite sufficient.

69. Now for testing, it is not necessary to write down any offset lengths at all. The Testing Officer is not likely to get the same measurement as the Surveyor, but a difference from 1 to 3 inches is to be expected. But this difference will be too small to be detected on the detail map. Therefore if the measurement taken by the Testing Officer when applied by scale to the plotted map does not give a perceptible difference, the work is quite sufficiently accurate. Therefore, for the purpose of test there is no need of writing any measurements down; but to assist his memory or in case of need of rechecking part of the work, and to give some materials for writing actual dimensions into Sanads, the Surveyor should write down the lengths of the sides of houses or other boundaries of properties when he actually measures them, and also the lengths of some of the leading offsets and such dimensions as the width of steps or gutters which are likely to be disputed and where it is not easy to plot with so great accuracy as might be desired. A step projecting on to a street ought not to be allowed to be doubtful even for a matter of 3 inches which is too small to plot on any map, and therefore it is advantageous to write down on the original map such dimensions. But it is most important that the map should not be crowded up with superfluous figures. Certainly not more than 2 or 3 figures for each ordinary property should be written down. In area calculation (para. 78) it will save much time if the sides of some of the rectangles are so recorded. The scale will be needed only for the remainder. The working lines such as the compass arcs and P. T. rays and offsets should be cleaned off almost as soon as they have been drawn, and the point required has been fixed. When the day's work has been finished, those parts of it which are sufficiently complete should be inked and the dimensions which it is desired to preserve should be inked, and other pencil marks and unnecessary particulars should be cleaned off with the rubber. This inking must always be done with good *waterproof* ink, whether it be black or red.

70. The method of testing will be to examine the work in the street while it is going on. A Head Surveyor can visit the work of at least 3 men per day. He will re-check some of the offsets or rays lately taken. He will measure the sides of houses and see that they agree with the plotted dimensions. If the base line has been taken up, he can relay it and check some leading offsets, but ordinarily he should not waste time in this way, but should test the work which is just going on, so that there will be no necessity to go back to other streets. Not only should he test the measurement work and see that the Surveyor is observing proper methods, but he should see that all his implements are there *and in good order* and that he is using proper judgment in distinguishing open from built-over spaces and that he is keeping notes of disputes and doubtful points for E. O. to settle. Also he should see that what appear to be private streets or public streets are not being measured or mapped as private property *occupied* by individuals. The Testing Officer should then sign the sheet and put the date and fact that he has tested it. There should be 3 or 4 test endorsements on each sheet before it is finished.

71. It has been laid down that we must be able to distinguish with certainty in a C. T. S. map any distance exceeding 6 inches. Therefore, we cannot adopt a smaller scale than 50 ft. to the inch; because that would make 6 inches only 1/100th part of an inch which is almost too small to be drawn. The scale we should use must lie between 40 and 20 ft. to the inch. Indeed, 25 ft. is a very fair scale for the minute internal details of our cities. 40 ft. was used in Bombay City where on the whole streets and properties are a little larger than in Mofussil cities. 20 or 25 is the best scale for cities with very small houses and

by-ways, and 40 ft. would be suitable in more open places, such as Dhulia. 33 ft. is a scale which has often been used in the past, but is very inconvenient, particularly as we cannot now easily get scales divided into 33 parts. With a scale of 25 ft, one square contains 625 sq. ft., so that 70 squares go to the acre (43,560 sq. ft). At 40 ft. we get 1,600 sq. ft. to the square and about 27 squares to the acre. But we cannot prescribe a fixed number of squares or a fixed number of acres to be mapped in a given time. It depends obviously upon the density of the work. If we divide the number of properties by the number of squares they contain, we get what may be called the 'factor of density'; *e.g.*, if 9 properties cover 24 squares, the factor is ·375. Density factors of 2 at 25 ft. and 4 at 40 ft. to the inch mean great density, and would indicate that the scale of 40 ft. at any rate was too small. The best way of determining a proper output for the Surveyors is to fix a sliding scale (such as is given in the margin: though we have not yet got enough data to lay down the scale with confidence) of squares decreasing as the density increases. Each Surveyor should state in his diary the number of squares and the number of separate properties mapped. We should not consider the output of one day by itself, since sometimes almost the whole day may be occupied in laying base lines or such work as prepares for the next day's mapping, but we must consider the figures for the month of about 24 or 25 working days. When a property covers a large area it takes longer to measure than a small property, but it does not take twice as long as two properties in the same area, nor four times as long as four properties. Therefore the reduction in the output of squares will not be in strict proportion to the increase of density. In Bombay City for the whole of the Survey, the average output was about 24 squares per day at the scale of 40 ft. (60 squares at 25 ft.), or ·88 acres per man per day for the whole area of 12,545 acres, but the general density was not high. The Surveyors were of the class of village officers, but brought from Northern India. The scale for any one place should be fixed and adjusted from time to time with S. L. R.'s approval by the officer in charge, so that slack work may be noted and good output should always be rewarded by a bonus when the scale is exceeded. At 25′ scale, 5 properties (16 squares) with a density of ·33 (and more or less according to the sliding scale), and a bonus of 4 annas for each property in excess of this standard is being now tried. Such difficulties as heavy traffic and argumentative householders and much internal measurement and sloping ground must be allowed for by slight reductions, and contrary conditions by slight enhancements.

25′ Scale.			40′ Scale.		
Density.	No. of properties.	No. of squares.	Density.	Properties.	Squares.
2	12	6	2	10	5
1	10	10			
·66	8	12	1	8	8
·5	7	14			
·4	6	15	·66	7	10
·3	5½	18			
·275	5½	19	·5	7	14
·25	5	22			
·2	5	25	·3	6	18
·175	5	30	·25	5	20
·165	4½	27			
·125	4	32	·2	4½	2
·08	3	36	·15	4	26
·05	2	40	·1	3½	35

72. The system prescribed in this Manual requires practically no recess or office work for the Surveyors. Their work can go on all the year. During heavy rain or excessive heat, a greater proportion of office work must be found for them, and leave—casual or privilege or otherwise—should be given in the hottest months or in the height of the monsoon. Writing up Registers, area calculations in arrear, inserting names of streets and buildings, or the tracing of finished sheets (if allowed to be done locally) may be taken up on days when out-door work is reduced or cannot be done. Ordinarily, work should be done from early morning till about 10 a.m., then an interval for meals and rest; then again office work from 2 or 2-30 to 4 or 4-30 according to season; and then again field work till sunset. When working out of doors, the Table on which the map is mounted should stand in the shade when possible, and when the sun is hot a large umbrella should be provided.

73. *Labour.*—Stones for the Theodolite work should be set up by contract (and the observations should not be taken till after they have been put down). When Chain and Cross Staff and bamboos are used as the implements, a large

number of men are needed. Every bamboo must be separately held up, and a chain is heavier than a tape. But with the equipment described in this Manual, Theodolite flags stand by themselves in tripods ; flags marking property limits are driven into the ground and stand alone ; the tape requires only one man or boy at the other end. A man to carry the Theodolite or the Plane Table and map and another to carry rods and other equipment ought to be enough labour for any Surveyor. For such trifles as holding the end of a tape or string, often bystanders or householders can be found in the street, quite willing to help. Such assistance should be encouraged, as the people must understand that the less the operations cost the less survey fees will be levied. It is always desirable that each Surveyor should have one *permanent* labourer or peon working always with him on a monthly wage, who can learn his methods and requirements, and so save much of the time and trouble involved if men are constantly changed.

74 *Entrance into houses.*—The law is contained in Sec. 200 L. R. C. and requires that a notice should be served not less than 7 days before entry, and that due regard should be paid to social and religious prejudices. After such notice and provided such regard is paid (*i.e.*, by not insisting upon the entry of a man of low caste into the kitchen or God-room of a higher caste, and so on) then any resistence to such entry becomes a punishable offence. Small printed notices should be prepared intimating that it may be necessary to enter the house to which it is affixed for the purposes of the City Survey on or after a date not less than 7 days ahead. Such notices can be affixed to the doors or walls, which will constitute sufficient service, unless the occupants of the house accept delivery ; *see* Sec. 191. Ordinarily, no unreasonable objections are raised by the people, but where obstruction is anticipated, as for instance where Parda is strictly observed, there may be some difficulty, and the notices must be carefully served.

75. In what circumstances is entry necessary ? In many old surveys, a very objectionable practice was followed under which the Measurers entered into every house in order to take its internal dimensions, on the plea that unless they did so they could not determine whether or not there was a small bend in the inner walls. We have even seen people required to move their furniture out in order to allow a stupid Measurer to measure a distance along a wall which could just as well have been measured across the middle of the room. Such practices, it need hardly be said, would be extremely unpopular and must not be allowed. Take the instance in Fig. XIX. All the external measurements of houses A, B, C, D having been taken, it might be assumed that the point O where the four meet can be determined by simply drawing straight lines across, but actually the internal arrangement may be as shown in the second part (*b*). Here obviously this could only be determined by entering one of the four houses and examining the length of the central wall. In taking such a measurement internally, the Measurer must remember that the approximate thickness of the wall must be added. The distance ON internally may be 10 ft., while MS externally is 13 ft., but if the walls are 18 in. thick, this is quite in agreement. It would be difficult to obtain the distance NO in the houses A or B if there were a cross wall as shown. But the Measurer should find one of the four houses which it is convenient to enter, and where the measurement can be satisfactorily taken. When determined in any one house, that is enough for the four. It is generally sufficient to judge by the eye, looking in through the open doors, whether the walls internally run straight ; also occupants may be asked, but when no satisfactory information can be got and when the straightness is not obvious or when on looking into house C it is plain that there is a substantial bend in the wall between O and R, then entry must be made, and this boundary must be examined and plotted from the inside. Of trifling discrepancies of only a foot or so like OR in Fig (*a*) it will be best to take no notice. Often they are due only to the carelessness and inaccuracy of building operations. Many internal walls are not absolutely straight, but this is accidental and not intentional. When however the difference is important, there is no way of avoiding a certain amount of inquisitive entrance. In the second figure it is obvious that very wrong results would be obtained if we had just drawn straight lines across and

assumed that the houses were all simple rectangles. Allowing for the thickness if the walls, it will usually be sufficient to measure one house of the set.

76. A device that is possible in some towns (*e.g.*, in Bagalkot it was employed) is to go upon the flat roof by means of a ladder and then measure the lengths of these internal walls from above where there are no obstacles or furniture When these measurements have been taken and plotted (carefully excluding eaves and projections) it must also be enquired in such cases which of the walls are common to the two houses and which of them are the separate property of one house only In Ranibennur houses were even found which had no external walls at all, but were entirely buried and enclosed in other houses through which the only access was obtained. *See* also 322 and 323 in Fig. XX(*a*). In such cases of course it would then be indispensable for the Measurer to enter and take measurements inside the block until he had successfully plotted the buried house. Internal measurements need not be written on the map, except in the cases where they have disclosed important irregularities of shape. The plotting itself gives the dimensions adequately, and a good painter would scorn to be required to write "This is a cow" under his picture of the animal.

Fig. XX(*a*) is a reproduction of part of the map of Shikarpur City. In this city, the density of buildings seems to be greater than anywhere else. Not only is about 90 per cent. of the total area built over but many houses are so deeply buried among other houses that it is quite impossible to plot them without internal measurement, allowing also for the thickness of the walls, which is apt to vary even along the side of a single house. Not only is the ground floor densely crowded, but in many places houses are built wholly or partly over other houses. In such cases, of course we can map the ground plan only; the right of having a house resting upon a second house is *an easement*; which should be noted as belonging to the upper house. The points marked A in the Figure could never have been plotted correctly without internal measurement. In such circumstances, of course, land values are very high on account of the excessive congestion, and Survey cannot possibly be done cheaply, since no labor-saving methods are practicable.

In Fig. XX(*b*) a photograph of some of these congested blocks is given to illustrate what City Survey sometimes has to face.

77. When the field work has been completed for a part of a sheet and it has been inked up with *water proof* ink, the next business is to take out the areas and then to number the properties. In the first place, the running number for the sheet should be given in any order the Measurer chooses to adopt, taking care that houses which are not to be mapped in his sheet (*vide* para. 66) are left to be numbered in the other sheet: if they are divided for mapping then they should be numbered in the sheet which contains the greater part.

78. *Areas.*—The area of an individual plot is quite easy to obtain. A great number of city plots are rectangular or rectangular with some slight projection on one or more sides. Here the rectangle can be measured rapidly and exactly with an ordinary scale applied to its sides, and when there is a projection (which is also commonly rectangular) that also can be measured directly without difficulty. When the plot is not rectangular, we must then use the scale and offset scale. The offset scale is so constructed that it can readily be moved up and down the face of the principal scale and so enable us rapidly to measure a diagonal with the main scale and its offset with the small scale, without being obliged to rule the base line or offsets on the paper, *see* Fig. XXI. With a little practice with these instruments areas can be taken out just as quickly as with the area square and with greater accuracy. When, therefore, we can divide our property into more or less perfect rectangles we should scale their sides and write down the product as the area, adding projections, &c. When the plot is not rectangular, then divide it into as many irregular quadrilaterals and triangles as necessary, and then measure the diagonal and offsets of each quadrilateral and the base and vertical height of each triangle with the two scales.

The areas of large irregular plots and open spaces can best be obtained by the area-square, as now specially printed at the Photozinco office. A test of

the relative speed and efficiency of the three methods of area calculation of various kinds of plots by area-square, area-comb, and by offset (waslewar) calculation, was made in 1917. The result showed that while the area ascertained by offsets was most accurate, the difference between it and the area-square calculation was too small to be worth the sacrifice of time. Area-comb is less accurate.

	No. of plots tested.	Average No. of plots calculated per hour.		
		Square.	Comb.	Offsets.
N. D. 152	...	10⅓	8	3½
C. D 133	...	15	10	5½
S. D. 130	...	20½	20	3½

The offset work must have been done very slowly and clumsily; quick and practised workers would not require nearly 15 to 20 minutes for an average plot. Simple rectangular plots would take only a few minutes each. For a Surveyor calculating his own areas daily, it does not require ½ hour extra.

Thus we obtain the area of each occupied plot (*see* sample in Fig. XXI). It then remains to find the area of the streets and open spaces not included in any plot or property. We might here take out the areas with the area square or the offset scale and add them all up, but since we have calculated the area of each plot and there must be minor errors of a few square feet in almost every plot, it is no use trying to take out the public and private street areas for the whole city with very great accuracy. It will be best after ascertaining the area of all the properties on one sheet (and making allowance for those portions of houses which project beyond the sheet) to find the net total area of occupied or enclosed properties on that sheet. Then since we know the number of square inches on the sheet, we know its total area, and if some portion of the rectangular sheet is outside the City Survey limit, then we can easily count the number of squares shown outside, and write down the "net area under detail mapping" on the sheet. Deducting from that the total occupied and enclosed properties, the remainder must be the total area of streets and open spaces. Some of the more important open spaces may be separately extracted and added; and since private streets are separated from the main roads the area of private street may be found separately from the area of public street.

79. When we have added up the results of all the sheets we get the gross area of the whole city. And then to avoid serious errors we may independently find out the area of the whole city in this way:—We made the Great Traverse more or less closely round the periphery of the area of the City Survey. Sometimes this traverse went inside the boundaries and sometimes it went outside and the whole was then plotted on a map at 200 ft. Now, we can without difficulty find the areas of the portions of the C T. S. area which run outside the Great Traverse and the blank areas where the Great Traverse is outside the C. T. S. boundary, and by adding or subtracting these areas to the area contained within the Great Traverse we get the "gross area within the C. T. S. limits." All that we then require is to know the area within the Great Traverse.

80. Now it is quite easy to find the area enclosed by any traverse when once its co-ordinates have been worked out. Take the simple illustration of the traverse A B C D in Fig. XXII. Draw the meridian OPQR, the zero North-South line from which the East-West ordinates of ABCD are measured. From ABC and D draw the perpendiculars to the meridian at OPRQ. Now it is clear that the area enclosed by ABCD consists of the two quadrilaterals OABP, PBCR, less the other two quadrilaterals RCDQ, QDAO. We may speak of these as the quadrilaterals upon AB, BC, CD and DA. It will be observed that we

add together the areas upon the two traverse legs which run from North to South (*i.e.*, AB, BC) and then subtract those which run the other way (*i.e.*, CD, DA). It only remains to consider how we get the area of the quadrilateral upon the traverse leg AB. Plainly this is got by multiplying OP by the mean between OA and PB, or we may say $\frac{1}{2}$ (OA + PB). But OP is the difference between the south co-ordinate of A and the south co-ordinate of B; while OA is the east co-ordinate of A and PB is the east co-ordinate of B. If, therefore, we add to the Traverse Book form, p. 8, three more columns (1) for the difference between the north-south co-ordinates at the extremities of each leg, (2) for half the sum of their east-west co-ordinates, we can then in a third column write down as product (3) the area of the quadrilateral upon that leg, with its proper sign + or —. If we call those which are to be added, or the south legs, "plus", while the others or north-going legs are called " minus ", then the algebraic sum of these areas gives us the exact mathematical area included within the traverse ABCD. Now this is equally true if the traverse has 50 legs. The formula is :--Let $\frac{N}{E}$ be the $\frac{\text{North}}{\text{East}}$ co-ordinate of a station, and $\frac{N'}{E'}$ the $\frac{\text{North}}{\text{East}}$ co-ordinate of the last station. When the co-ordinate is South, call it -N, and when West -E. Then the area of the quadrilateral upon each leg is $\frac{1}{2}$ (N — N') (E + E'), and will be positive or negative according to the signs of these quantities: the aggregate algebraic sum of the areas is the area of the whole Traverse.

81. Having ascertained the gross area and the area as made up in detail bit by bit from the sheets, we can then compare the two without expecting exact agreement, but expecting an agreement within such percentage as will show that we have not made grave errors in the calculation. The gross area within C. T. S. limits should be carefully preserved, as it is very likely to differ from that previously obtained in the cadastral surveys, and should be substituted for it in the Land Records. We have also got the individual area of each property.

82. The next step will be to make a list of all the properties in each sheet, in the rough order of the running numbers which have been given by the Measurer: indeed the Measurer should be required to write up the first four columns of the Enquiry Register. These columns are :—

1 Current or Chalta No. in the sheet.

2 Old Municipal or Street or Revenue No., if any.

3. Area.

4. Supposed name of holder as in Municipal Records, or otherwise.

83. There should be a separate portion or volume of the Register for each sheet. It will be understood clearly that the Measurer is in no way to attempt to do the duty of the Enquiry Officer. If there is any dispute, he will make no attempt to decide it but will simply enter it as " Disputed," putting the names of the disputing owners, &c. He may also say whether the alleged or supposed owner is the mortgagee or purchaser, or any other such information as easily comes to him. The object of these entries is to give the Enquiry Officer something to start on: a list of the properties corresponding to the map and some idea as to the person to whom the notice should be addressed. There will of course be other impersonal notices served on the property itself, and no harm is done if the name first put down is wrong. E. O. must not assume that it is right. When this has been done, all is ready for the E. O. to whom the papers will then be handed over. If the Surveyor has noted down any disputes as to boundaries or the like (*see* para. 61 above), these will be specially referred to in the Enquiry Register so far as he has prepared it, and rough notes may then be destroyed. E. O. may very likely find that the boundary is not as laid down by the Measurer. Then of course he will correct it and this will involve correction of the area. In fact, some properties which were originally put down as separate may now be joined to others, and undivided properties may be divided into two or more parts. All this would be first corrected upon the original map by a Surveyor who will work with the E. O.

CHAPTER IV.

Numbering.

84. The problem of numbering has already been dealt with to some extent while we were discussing the division into sheets. It will have been gathered that the final numbering which is not hampered by the limits of sheets, but runs serially through large blocks or wards in the city is a sort of work of art as to which rules cannot exactly be laid down. We must remember that when once a number has been given which is not absurdly arranged even though it cannot in all respects satisfy everybody, and even although there might be a dozen other methods of numbering the same houses, still the important thing is that when once a number has been given it should be rigorously adhered to. The current or chalta Numbers originally given will entirely disappear and the only Nos. which will be printed are the final Nos. No old Municipal or other such numbers will be preserved, except in the records, *e.g.*, the Enquiry Register. Government expect (R. 5000-16) all Municipalities will abandon their own separate numbering and adopt for all purposes the City Survey numbering, and of course this involves the supposition that the City Survey numbering will be intelligently done and will satisfy most people

85. Now for any purpose whatever, numbering like this is no use:—6, 2 17, 1, 5, 9. We must have numerical sequence. Now, let us suppose properties numbered as in Fig. XXIII. No. 17 is a large undivided property. Between 18 and 19 there comes a block of unoccupied land, and between 19 and 20 there is Revenue Survey No. 128. Now if we leave things like this, then in years to come No. 17 may be divided into several parts, and the unoccupied land may be given out plot by plot at different periods, and the same may happen to the Revenue Survey No. 128. Now when 17 is divided if we give a new number, such as 240 to the second part: and in the unoccupied land if we give new numbers to each plot as it is given out in the order of granting them, and then we do the same in the Revenue Survey number or—equally bad—we retain the old No. 128, we shall then get exactly the sort of series of numbers which a few moments ago we said was no use. Therefore, the rules must be these:—(1) When any existing number is subdivided, the number must be retained with the addition of letters or figures like 17(1), 17(2), or 17(*a*), 17(*b*). If these again are subdivided, then 17(*a*) must be split into 17(*a*-1), 17(*a*-2). (2) All unoccupied spaces must be given numbers, there is always a likelihood of their being hereafter used for building. (3) Revenue Survey numbers though not now built upon but standing amongst the series of City Survey properties where it is probable they will afterwards be built over, must be given a provisional No. to be brought into use hereafter when building takes place and when the land consequently falls under the City Survey and comes upon the Enquiry and Property Register. Therefore, the series of numbers as we first wrote it down was not correct, but should be as shown in the second line in Fig. XXIII.

86. The sole object is to get a single system of numbering for all purposes. A case has just been seen in which it is reported that owing to two or three systems of numbering in a certain town a great deal of the time of the Municipal and City Survey staff is occupied in this way:—when any application about permission to build or rebuild, &c., is received, it is first necessary to find the applicant and let him point out the exact space referred to before it can with certainty be identified with any of the City Survey Numbers. This means something like half a day's work wasted in every case. If the Municipality has already got a series of assigned Numbers which is good enough not to justify the trouble and expense involved in the substitution of a new series, then by all means accept the existing Numbers; particularly when enamelled plates have been provided, or Numbers painted upon plates have been already attached to the houses. But if the Municipal numbering can be demonstrated to be entirely unintelligible and impractical, there is no alternative to a new system. When good numbering is so accepted it will become the C. T. S. numbering.

87. Municipalities sometimes divide one property for taxation purposes into subsections; the City Survey sometimes gives two or three Numbers to a property which the Municipality treat as one; sometimes the City Survey numbers open spaces or Government spaces, &c., which do not figure in the Municipal series at all. We may adapt a series of Municipal Numbers for City Survey purposes, thus:—

Munl.	*C. T. S.*
17	17
18	18-A, 18-B, 18-C.
19	19
20	20
	20-A
	20-B
21	21-23.
22	
23	

Here the Municipal No. 18 covers three C. T. S. Numbers; while after the Municipal No. 20 there come two plots which the Municipality has not numbered; and then the three properties 21, 22, and 23 which are one for C. T. S. purposes. Yet as shown above, it is possible to adapt the Municipal series and use it for our City Survey maps.

CHAPTER V.

Enquiry.

N.B.—In his Memo. No. 2798 of 23-10-17, the Remembrancer of Legal Affairs writes :—"A very cursory review of legal principles is more apt to be misleading than to be of service This chapter cannot be corrected with any advantage, because it requires reconstruction. If a reliable and useful treatise on the subjects dealt with were to be prepared, it would probably be too lengthy for inclusion in the Manual, and in any case considerable time and leisure would be required for its preparation."

This chapter has in deference to that opinion been much curtailed. It must be very distinctly understood *not to have been cited by Government, who are not bound by any opinion herein.* It is a sort of "ranging shot." When the worst errors have been pointed out and some of the moot points decided, we can have a fresh edition with a lower percentage of error. Perhaps some day the R. L. A. will be able to give us an adequate monograph ; meanwhile the E. O. must have some guidance. The present collection of most of the known rulings and orders of Government and the Courts cannot fail to be of some use to him. He can at any rate look up the original authorities and interpret the law according to his own judgment. Hitherto he has had no compilation or guide whatever to these orders and decisions.

With this foreword the following outline of the subject is presented ; little more than references to the law itself and to Court and Government rulings have been retained, in order to provide an E. O. without special judicial training with some guide to the literature of the questions he is certain to encounter.

This is the operation which the whole City Survey subserves; the due ascertaining and recording of titles not only for fiscal but for legal protection and for the confirmation of all existing good titles.

88. The object of the enquiry is to determine for each parcel of land who is entitled to be confirmed in possession, and what possessions are mere encroachments, easements, or licenses: then what residue of land vests in the Municipality or Government. If the land is adjudged to be in the legitimate possession of a private individual or body, then the next question is whether it is liable to pay revenue or not, and to whom; and on what terms or tenure it is held ; also if it appears to be a recent and illegal occupation, whether any action can be taken to recover it for public or Municipal uses. In dealing with the claims of private individuals amongst themselves, not only all these questions of possession, limitation, &c., may have to be dealt with, but also the whole body of the civil law of inheritance, conveyance, mortgage, and much else. This obviously is a subject from which we must entirely abstain, but we may say that a judicial officer is better equipped for dealing with them than a revenue officer, and the Enquiry Officer should certainly decline elaborate trials of title, since in these issues between private parties he is simply a revenue officer acting (usually) under the Record of Rights law.

89. All land which is not possessed by or the property of any individual, however large or however small its extent, is naturally the property of the community (or the Government as representing the community), and this is expressly declared by Section 37, L. R. C. The Bombay Government have invariably, whenever the point has been under discussion, always reserved (Government Circular R. 3361 of 12-6-73; R. 4239 of 24-7-73, 5292 of 22-9-73 and 2065-80) the proprietary right in the soil of all village and town sites, even though such sites are possessed and occupied by many persons. They have admitted occupiers to the privilege of holding these occupied sites free of taxation (R. 4344-86), and have fully recognised the heritable and transferable nature of the tenure in which they are held in private possession. But they still maintain all rights to minerals, and the reserved trees, and residual rights as reversionaries, and the right of taxation when they think fit to exercise it (Section 45, Cl. 2, L. R. C.) and apparently also the ultimate ownership of the soil of public streets. In occupied sites brought under City Survey, under Act IV of 1868 and present Code, there has been a policy of surrendering this right of taxation in perpetuity; but the matter is under consideration.

It is frequently claimed by Government or the Municipality that possession has been taken from them by a recent encroachment which should not be recognised. One first question, therefore, arises as to the circumstances in which a later possessor can acquire a better title than a former possessor.

We must first see the Law of Limitation which is of great importance to all rights of property. Against any private person seeking to recover possession of land an adverse possession of 12 years bars his suit. Against a Municipality or Government the period is 30 and 60 years, respectively (Art. 146 A and 149, Limitation Act XV of 1877 as amended by XI of 1900 (*s-e* note to para. 96).. But it must be noted that the possession set up against the claim must be *adverse, i.e.*, it must be a possession so open and assertive that the other party cannot have been ignorant of it. The strongest form of possession is adverse possession for the period prescribed by the Limitation law, because that possession practically ripens into full title. The next degree of possession is what has been termed "juridical" possession. Here there is a possession and use of the land regular and systematic, though possibly not all the time known to the other party, but still a fairly continuous possession not interrupted by any retaking of possession or adverse exercise of rights by the other party. If two persons went each on alternate days to the same plot of ground and made the same use of it, but neither met the other, the possession of neither could be said to be complete, and the possession of neither is adverse to the other but "fugitive and unimportant user." This state of things may arise in respect of waste grazing lands. There is neither "juridical" nor adverse possession and the land is therefore unoccupied. But when a person has enclosed a piece of land and has systematically used it for a reasonable period [the law leaves it a matter of discretion and commonsense as to what period will be sufficient, but in order to be effective against Government it need not be anything like 60 years (Advocate General in R. 1873-96)], then he acquires a sort of half-way-house towards a good title. This possession is protected by Section 110 of the Evidence Act, which lays down that if such possession is proved then the person in possession (or recently dispossessed but able to prove such recent possession) shall be placed in the position of defendant, which is the stronger position, and the person claiming to dispossess him is under the onus of proving his full title, or at any rate a much better title than the defendant, before the Court will give him a decree. If Government can prove that within 60 years land was unoccupied and therefore *in possession of Government,* then that is a good proof of *title* (R. 9661-96).

90. When P is the possessor of land and T is the person with title seeking to dispossess him, P while still in possession can obtain a decree prohibiting T from interfering till T has brought a proper suit against P and proved his full title and that he is not barred by limitation and that P is a trespasser.

91. If however P is dispossessed by T, he can then *within six months* (Art. 3 Limitation Act) of dispossession appeal to the Court for protection under Section 9 of the Specific Relief Act, and the Court will restore his possession (the English action of novel disseizin) without investigating title, if he was dispossessed otherwise than by proper course of law. This is reasonable, since violent or deceitful dispossession is an attempt to evade the necessity of proving title and to throw it upon the dispossessed P. When there is no time to appeal to the proper authorities, the criminal law gives P a right of self-defence against such dispossession by any party other than Government, and mere juridical possession is quite enough. But *after six months* and within 12 years P can still sue to recover possession. To succeed, P must first prove his old possession, and either a '*prima facie*' title or that the interloper is a mere trespasser (Ismail Ariff *v.* Mahomed Ghaus, L. R. 20 Indian Appeals, p. 99). Then the onus of proving a full title is shifted upon T. This onus would not dismay him if his title is really good. Thus the person who has been for a reasonable time in possession has a very strong prospect of recovering possession if he takes action before limitation steps in: an easy case within six months: a more difficult case within 12 years; after 12 years, no case at all. But when P is still in possession and T with the good title sues to oust him, the full onus is upon T. Again, the law does not allow any person who enters upon possession as a tenant or licensee ever to acquire adverse or even juridical possession as against the title of the person who gave him possession (Evidence Act, Section 116).

92. Let us see whether in any of these cases the position of Government differs from that of a private person. We have already mentioned that the

limitation against Government is longer. Again, the Specific Relief Act cannot be used against Government, nor the right of private defence. Then again it was supposed (R. 9661-96) that the person in possession when ousted by Government alleging a title could not recover possession against Government without proving *his title*, but in I. L. R. 25 Bom. 287 it has been decided that proof of 'juridical' possession and the *prima facie* title implied in such possession is sufficient to enable him to recover possession, unless Government clearly prove their title to be superior and anterior. After possession has been so recovered, it is still open to Government in a fresh suit to prove a better title, subject to the 60 years' limitation.

93. *Streets and roads.*—In the Bombay *District* Municipal Act III of 1901, a street is "any road, footway, square, court, alley or passage whether a thoroughfare or not, temporarily or permanently accessible to the public" and falling within the ordinary meaning of street, which is a way or means of access between houses. Even if the street has gates and bars, still it is a street accessible to the public, if the occupier is not able to close it throughout the 24 hours [Section 3 (12), Bombay District Municipal Act]. This of course he cannot do, if it is required for access to other houses also. It seems that a street may even as to its soil be privately owned, but yet it cannot be used for any other purposes, if it has been made accessible to the public and is required for access to houses. When a street is not merely accessible but the public have a *right* of way, it becomes a public street. Any private street within their limits can be declared by the Municipality to be public, after considering any representations of objection or if they decide to spend any money on its repair, &c., [Section 90 (3) to (5)]. If it seems unreasonable that land undoubtedly originally private can thus pass to general public ownership we must remember that the conversion of part of an estate into houses involves of necessity the sacrifice of another part for public access. There remains a right of ultimate recovery if the land ceases to be a street.

94. It will often be hard to judge how wide a strip of land should be adjudged to be a street within the ordinary meaning. If there be a row of houses with miles of open space in front, we cannot say it is all needed for access and is all street. If there are two rows and access must be over the space between them, still if that space is 200 yards wide we cannot say it is all "street." Sometimes we find only 20 or 30 feet and even three quarters of that blocked; still a pedestrian or a cow can just get through. Is that enough for a "street"? Certainly not. The standard should probably be this; when there is enough open space (or space which can be *made* 'open' by rejecting encroachments) we should require a minimum width of 20 feet, as that enables two carts to pass without forcing pedestrians off the street. When there is less than 20 feet, no curtailment or infringement should be allowed on the plea that it is not needed for or does not naturally form part of the street. When there is more than 20 feet, it is a question of fact and proportion. Any obstruction or encroachment (even in a street 36 ft wide) is still an obstruction (Jessel M. R., in Bagshaw *v.* Burton, L. B. of Health cited in XII Bom. 474).

95. Now let us see how the general law as to possession, &c., will apply to lands bordering upon streets. Even if the owner of a block of entirely private land builds houses and lets them to tenants [it might even possibly be the same if he gave them to be occupied by different members of his *own family*], then the land between and giving access to them or reasonably necessary for this purpose becomes a street and would pass under Municipal control (I. L. R. 30 Bom. at page 569). The remarks of Jessel M. R. cited in this judgment are very apposite to the case of the choks or enclosed spaces and khidkis in the towns of Gujarat. Private land can thus become public, just as public land can by prescription and lapse of time become private.

96. The erection by sufferance of rough temporary structures upon a street is not 'possession' sufficient to put the occupant in the position contemplated by Section 110 of the Evidence Act (11 Bom. 338). Other uses

which have been definitely ruled not to constitute "juridical" possession are the stacking of grass or wood (I. L. R 16 Bom. 338) or throwing of rubbish upon part of a street. When the street is moderately wide and the inhabitants are cultivators and keep cattle, it is a very common habit to tie up cattle in front of the house and by degrees to enclose a space and roof it over. This habit also must not be allowed to develop into proprietary claims (R. 4727-09). At what stage this passes from a mere use into 'juridical' or further into 'adverse' possession is very difficult to determine. But we might say that when solid pillars or brick walls are put up to enclose the space, this constitutes practically a declaration of possession, and the possession would from that time at any rate begin to count as adverse, in any subsequent claim by the Municipality or the public to the right of way and use of the street. When not so solid, the occupation even of a plot of ground round which brushwood or galvanized iron sheets or other temporary and easily erected, easily removed structures have been constructed, does not become 'juridical' possession (it is a mere act of user, I. L. R. 16 Bom. 338), and therefore if the Municipality dispossessed him on the ground of the land being part of the public street the holder would not only have to prove that he was in this sort of flimsy possession but would have to prove a *title* before he could recover possession. Even if he recovered possession, still the Municipality might be able thereafter to prove a better title and oust him by regular suit. The chief point in favour of the Municipality would be evidence that within 30 years the land was a public street and therefore vesting in the Municipality. We could also collect evidence that such user is always made by agriculturists, that they often describe in their documents this piece of street land in front of the house as their own property, or call it "their" chok or angna without meaning much more than that the house has this 'facility of user' over this portion of land, just as they might also say that the house has a door with right of way on to the street in front, and with right to light and air from the said street, or other easements as to water, &c. Again, when the existence of other cattle sheds separate from the house, or of an 'osari' or place for cattle in the house itself, can be proved, that also would tend to weaken the juridical possession and reduce it to a mere user, by license of the neighbours, owing to the weakness of public sentiment about the occupation of street lands.

We may also tender evidence that the Municipality has been in the habit of removing such users or encroachments whenever a case was brought to their notice, or caused annoyance to the public. Evidence that such land was mentioned (or even its exact dimensions given) in private documents as private land might be argued to have no value. It would not make a street (as described in para. 93 above) any the less a street, if A described it as "my chok or angna in front of my house." Even if more than 30 years old, such a declaration in a private document would not approach the level of an 'adverse' possession or assertion of title, as the Municipality and the public could not know of such assertions in documents to which they are not parties. The R. L. A. in his letter to the Collector of Sholapur, No. 2046 of 27-7-14 also opines that the erection of huts by the depressed classes on waste land outside a city does not constitute evidence of title as owners.

It follows that E. O. should refuse Sanads for mere trespass and encroachment, and when he finds that juridical possession is established, he will require the Municipality or Government to prove their title, and will refuse a Sanad to the trespasser, if they succeed.

Though private streets do not vest in the Municipality they have an interest in them [Section 90 (3) and (5) Dist. Mun. Act] and could apparently join in resisting attempts to convert them to other uses.

The thirty years' limitation was first enacted in Act XI of 1900. Before that date the period as against a Local Body was 12 years; therefore any encroachment amounting to actual or juridical possession before 1883 would have ripened into title by 1900: but if it did not commence till 1889, it cannot mature into title before 1919 (*see* R. 3251-17, G. 1510-17).

Easements.

97. Besides proprietorship law and practice recognise other rights over land which may be owned or possessed by persons who are not proprietors of

the land itself. The commonest example is a right of way; again the right of having balconies and eaves projecting beyond the wall to shelter the wall and to clear rain drippings away from its base is another [Section 7 (*d*), Easements Act] or the right to build part of a house over the top of another, or to rest beams on another's wall; so too the right of having eaves draining upon the roof or land of another owner is frequently in dispute. The right to place a flight of steps, resting at one end on the public road, to give access to a high-plinthed house; the right to have doors and windows opening on to a plot belonging to some one else or to Government or the Municipality, so that no building can be erected on that plot in such a way as to block the 'ancient light' or the doorway; the right to discharge waste or sullage water (apart of course from any sanitary prohibitions that may be imposed); the right to use the water of a well on the land of another person; all these are rights of easement. Ordinarily, rights of way are not mapped but indicated by marking the existence of a door at the position served by a passage or open space. Steps are usually mapped; if they form part of the property they are enclosed in its boundary line; if only an easement, they are excluded (*see* Fig. XVII). Similarly, rights of tethering cattle or standing carts or storing produce may be easements even when there is no ownership of the land.

98. Now, how does an easement arise? It may be by grant, or by prescription and use. The matter is dealt with in the Easements Act V of 1882, Section 15, which prescribes an uninterrupted use for 20 years or 60 years if it is claimed against Government; hence in R. 4548-16 the Collector of Surat was directed to obstruct certain windows, just as private owners often erect screens to block light and air from reaching their neighbours from their land; every land-holder who erects buildings ought to provide for his own light and air upon his own land. Easements over Government land may not be *granted* except with the express sanction of Government or according to a rule or order authorising such grant. Unauthorised exercise of easements must be barred and interrupted (R. 3864-91).

99. When any easement is claimed, the E. O. should deal with it as if it were a plot of land attached to the dominant hereditament, and should record his finding in the Enquiry Register and Sanads. It may be observed that it is a common thing to find in deeds and private documents that the distinction between ownership and dominant easement is ignored. If A says "I sell my house together with the passage (of which he gives the dimensions) leading to the street" it is not conclusive that he asserts ownership over this passage. The language is consistent also with the assertion of an easement which he would transmit with the property but which would by no means debar the Municipality from claiming that the land over which it was exercised was a private street. In Government Selection CXXXV, p. 78, dealing with the City Surveys in Gujarat under Bombay Act IV of 1868, the effect of the practice in respect of balconies and eaves of taking Nadáva Kabulayats, or agreements to surrender an easement as a right and to enjoy it by license only, is discussed.

Enquiry Procedure.

100. The E. O. is usually an officer of the grade of Mamlatdar or Deputy Collector, who is gazetted under Section 18 L. R. C. as Survey Officer in charge of the City Survey (R. 6884-15) The time for his appointment is soon after the commencement, even if not at the commencement, of the Survey (*see* para. 10). His powers are derived from Section 50-A of the District Municipal Act of 1901 and from Sections 3 and 37, L. R. C. (both first enacted in 1912) and 119, 189, 193, L. R. C. He must also prepare a Settlement Register under Section 108, but if the population exceeds 2,000, he does not exercise any power under Sections 96-97 (Impressing labor and charging for it) because Survey Fees are levied, 101 (Irrigation rates), 104 (Remission of Assessment), 118 (Village Boundaries). If the population is below 2,000, it is better to use Section 135(*g*), L. R. C. Under the Municipal Act he decides disputes or doubts regarding the boundary of streets and other spaces which vest in the Municipality and whether streets are public or private; under

Section 37 L. R. C. he can decide similarly between private persons and Government; under Section 119 L. R. C. he lays down boundaries between private properties. The E. O. is usually in receipt of a salary (say) of Rs. 300 p. m.; his clerks and staff of peons, &c. do not cost so much as one-fourth of this. Therefore, it would be most uneconomical for E. O. to arrive to take up his duties and find no clerk, no office, no forms, no stationery, &c. Arrangements must be made by the Superintendent of Land Records to see that a competent clerk with forms, stationery, office, and so on is in the City and has commenced work (such as Notice printing, preparation of Enquiry Proceedings Forms) before E. O. arrives; only so can a good output be secured (*see* para. 129).

101. His procedure is laid down in the L. R. C. Rules (R. 8866-16). As a first step, a general notice (not the legal notice in Section 96, L. R. C., which does not apply) should be issued to all the citizens informing them of the inception of the Survey and Enquiry, and stating its general objects, and especially calling upon mortgagees and absentee owners to take care that their rights are brought before the E. O. when he makes the enquiry into their individual properties. When a sheet has been mapped and the Enquiry Register with its four columns tentatively filled in by the Measuring staff (para. 82), E. O. will then issue individual notices. A minimum notice of 10 days is required, and one must be addressed to the parties and another published on the land in dispute and at the specified public offices. In fixing a *minimum* of 10 days, it must be understood that if the parties desire longer notice or if they are not able to adduce their full evidence on the day of opening the proceedings, then E. O. must grant them all proper facilities either by increasing the minimum period, when he is conscious that it will be insufficient, or by granting adjournments when reasonably demanded. In his proceedings, he will hear evidence and receive documents, and he must remember that the Municipality or Government must prove claims just as well as private parties; he is not a Municipal or Government Advocate, though he may undoubtedly take cognizance of the obvious fact that land appears to be part of the street or that it has been shown in old maps or records as public or Municipal land. He is not bound by quite such rigorous rules as a Civil Court (R. 8720-91). He is appointed for the very reason that parties may put in their claims and that decisions may be reached in a less formal and expensive way; and it must always be remembered that if ever he does injustice by an unreasonable decision, the party can have recourse to a Civil Court, and in the event of success would win their costs. There is no *right* of appearance by Pleader before E. O (R. 840 90), though he would be ill advised to refuse to hear legal arguments in important contentions or test cases. Parties may, however, always appear by duly authorised agent or representative.

102. E. O. being a 'revenue officer' (Section 3 L. R. C.) can summon witnesses to give evidence or produce documents under Sections 189-190 and parties are bound to state the truth before him. He can administer oaths in *formal* enquiries, and (Section 4, India Act X of 1873) in his *summary* enquiries. The enquiries under Sections 37 (2) L. R. C. and 50-A Dist. Muni. Act, are formal: others are summary. Both formal and summary enquiries are judicial proceedings for the purpose of Section 193, 219, 228, I. P. C. *only* (R. 840-90) and he is a 'Civil Court'.

103. Before the enquiry commences, all available Municipal or Government records as to leases or past decisions in disputes of title or of possession should be collected and arranged. This duty might be imposed upon the E. O. and his office, though the Revenue and Municipal Officers in charge of such records must obviously assist him in finding everything. If the evidence of opposing parties raises presumptions against the records, he will require the usual evidence to rebut these presumptions, and the Municipality and Government must always be prepared to put in their evidence and records with the same formality as the private parties.

104. An important question is how far should a claim be regarded and dealt with as disputed? If a notice is issued and the party heard, however,

little objection he may have to offer, and a decision is formally announced, then the special limitation operates. But if this procedure is not followed, then after many years the party can again raise his claim saying that there was no settlement of any 'dispute' or contention by the E. O. under the L.R.C. Rules, but only an *ex parte* record by which he is not bound. Now if this door were left open for the great majority of properties it would be very little use having gone through the enquiry. Therefore, whenever there is any *decision* between the Municipality and the private party or between Government and the private party, the full procedure should be followed. Such disputes cannot arise where a private property is bounded on all four sides by other private properties, but *wherever the property is bounded by a street or open space,* the notices should be issued, and all cases should be primarily treated as disputed.

105 *Government Claims.*—When the dispute is between Government and the occupant, then the procedure is exactly the same, except that Section 37, L R. C. is used instead of Section 50-A, Municipal Act. The printed notices should, therefore, provide both sections. There will be far fewer enquiries under Section 37, but E. O. must remember that the limitation against the Government is not 30 but 60 years (*see* Limitation Act, Section 26 and Schedule I). The Land Revenue Code is shortly to be amended to improve the strength of the limitation barrier against the revival of disputes once decided under this section (R. 11312—13). In a Notified Area there is no "Municipality" and Section 50-A does not apply, but Government stands in its place (R. 7976—17).

All E. O.s are not possessed of great experience and legal judgment, and yet if a decision against Government, surrendering rights over valuable land, is once recorded there is no appeal against it. It is, therefore, desirable that the Collector, through the Mamlatdar or otherwise, should keep himself informed of any decisions against the claims of Government which are in any degree dubitable. The power of *revising* the E. O.'s order or of referring it for further enquiry or taking any other appropriate action should not be neglected, if the Collector is dissatisfied.

Unoccupied spaces claimed by Government might be entered as Government property and there could be no decision under Section 37 (2), because there is no claimant. The Waste Lands Act (India) XXIII of 1863 provides a special period of limitation of three years (Section 18) for claims to land sold by Government; but cannot be employed unless it is intended to sell the land or unless a claim is raised. It seems, therefore, best that a notice in Form V signed by the Collector should be affixed upon or alongside every such vacant plot, intimating that if any claim is raised it will be adjudicated under Section 37 L. R. C., but if no claim is received it will be entered as Government property. The fact of the issue of this notice should be noted in the Register. Then although the entry would not be conclusive against all possible future claims, still it would operate as good evidence of *adverse* possession from at least the date of the enquiry.

Vacant spaces bordering upon a street and not the proved property of individuals are Government property, and not Municipal (G. 871-75). The Collector will decide in a street of varying width which of such plots are Municipal, judging whether they do or do not form an integral part of the public street which vests in the Municipality (G. 2193—75).

106. *Municipal Claims.*—All *public* streets vest in the Municipality. It is for the E. O. to lay down what are the limits of the street and to record his decision. Herein the jurisdiction of the Civil Courts is not taken away (a subject upon which there has been considerable controversy in other spheres), but there is a special rule of limitation enacted with a view to bringing all disputes to a head and to a final settlement. *Interest rei publicae ut sit finis litium*; there is no title which would be safe from assault if it were not protected by the general laws of limitation, and when a City Survey has thoroughly investigated every claim, it is essential that after allowing a sufficient period for disputing any of its findings, thereafter the door should be closed for ever against further revivals of the disputes.

107. There is considerable vagueness as to the Municipal rights over land. Except when definite grants or purchases have been made no land is Municipal property which has not been dedicated to public uses [Section 50 (2) (*a*) to (*c*) and (*f*)] or definitely transferred to the Municipality by an order under Section 50 (2) (*e*) of the Municipal Act. It would therefore seem that there can be no power in a Municipality permanently to alienate any vested land or to grant it on a rent in perpetuity. It could do so only with land over which it had acquired full proprietary rights free of any assessments. When a Municipality purchases private land it holds it on the same footing as any other private owner, and could not claim exemption from any assessment to which a private owner would be liable. Nor can it confer any such exemption upon its assignees (R. 7596—17). To allow such exemption would constitute an alienation or transfer of revenue, present or prospective, to a local body, and such a transfer is beyond the powers [Rule 5 (5) in Financial Notification No. 2293—7-8-16] of the Local Government without the specific sanction of the Government of India or the Secretary of State. Municipalities are however ordinarily exempted (Rule 12, L. R. C. and otherwise) from payment of revenue on land which they have acquired for public Municipal purposes (*e.g.*, for a hospital), from which profit is not derived, but if those institutions or land are diverted to new uses which cannot be called public, then their title to exemption would be doubtful (*e.g*, slaughter houses in which the fees charged constitute a source of profit; boarding schools or hospitals for paying patients from which profit is derived in the sense of a surplus of income over expenditure and interest, &c., upon original costs). And certainly when land is leased out for building purposes to private parties upon rent, there is no title to exemption.

108. It remains dubitable whether the Municipality can be permitted to enjoy revenue from land which originally vested in them for the purposes of the Act but which they alienate. When a public street is not to be closed or abandoned, the sale (or lease) of any part of it is a dereliction of the trust under which it vests in the Municipality (R. 905-80, 5965-86); except only when under Section 93 its disposal improves the general line of the street. Otherwise it is hard to say that the disposal of any part of the street system improves it, or that it is not required (G. 1106-89) *see* also end of para. 94. If it is inexpedient to evict an encroacher, his occupation must not be regularised by sale, but left alone (R. 418—12). When, however, land ceases to be required as a public street (G. 2461-91) the Municipality under Section 90 (1) District Municipal Act III of 1901 has power to sell it by resolution of the General Body; and Government do not claim any share in such sale proceeds of the right of occupation (R. 3445-11, 447-12). Such sales are subject always to the sanction required by Section 40 (2) and (3), idem; and moreover they are subject to any unextinguished right the public or any person may be able to establish thereover (I. L. R. 1 All. 557 and 7 All. 362). There is a natural presumption that any road or highway or waste land adjoining thereto belongs to the owners of the soil of the adjacent land; and when no longer required for a road, the owner (usually Government) is entitled to re-claim its possession (I. L. R. 20 Cal. 732). But though the Municipality may sell the occupancy, they are *not authorized to lease it* (G. 447-03, G. 3461-08). A grant reserving a rent or revenue to the Municipality is not a sale but a lease, even if a premium upon entrance is demanded, and such a lease in perpetuity, or in defeat of the reversionary right of Government, is not allowed (R. 4511–00). A lease in any form is an attempt to reserve a right of re-entry to the lessor to which (since it is no longer required as a street and the vesting is at an end) a Municipality in such circumstances, is not entitled. It is true that in Section 90 (2) the Municipal Act gives power to the Municipality to dispose of certain land *which it has itself acquired* (*i.e.*, not the vested land) in perpetuity; but this is subject to sanction of the Commissioner, and the perpetual disposal of the tenure must not bar the rights of Government in respect of assessment or the reversionary rights in case the Municipality ceases to exist [Section 4 (4)]. Nor are the Municipality owners of the soil of the public streets which vest in them under Section 50 (2) but apparently only of the surface materials of the street and its pavings, &c., and of the *right of occupation* of the land which, so long as they hold it as a public street, is enjoyed free of revenue (R. 1890-91 and I. L. R.

and evidence are put in, then the papers of that case should be separate and should be filed in such a way that they can instantly at any time be connected 20 Cal. 732 following 7 All. 362, and 13 Cal. 171). Their property in these streets does not extend from the centre of the Earth "*usque ad cælum*" (I. L. R. 25 Mad. 635), but is a special right of property created by statute.

It would seem that Government are entitled to levy revenue upon such land [Section 45 (2), L. R. C.] and are not barred by the fact that it has long vested as part of a public street in the Municipality. Land so held by a Municipality free of revenue becomes liable to Government Land Revenue when the use is changed [Section 48 (3) L. R. C.].

The practice of allowing a Municipality to lease or sell any portion of the public streets for the benefit of their current revenue is opposed to sound policy; they are the custodians of the streets, and their consciences as custodians* should not be assailed by the prospect of getting current revenue from such grants, which they do not invariably set apart for productive expenditure in spite of R. 4342-73, 5978-73, and G. 3031-01. It seems that when the Municipality and the public do *not* require the land they may with proper sanction and for capital or productive expenditure (R. 3044—63) sell their right of occupation of the land, subject to the right of Government to levy the proper assessment on its new use; just as in the case of unoccupied lands sold for the benefit of certain Municipalities under the arrangements made for certain City Surveys under Act IV of 1868. E. O. will often have to investigate and obtain orders on such cases.

109. *Claims of private parties.*—The City Survey Records are undoubtedly Land Records. Therefore, if at any time after the Survey a dispute arises between occupants as to the settlement of a boundary or the decision of any rights which flow from such determination, it shall be decided by the Collector, and Civil Courts have no jurisdiction [Section 121 (1), L. R. C. and Revenue Jurisdiction Act X of 1876, Sections 4 (*g*) and 5, which is still in view of the General Clauses Act consistent with our new L. R. C. in respect of the disappearance of "recognised shares" from the Code of 1913]. When the Collector has decided such a dispute, he can then enforce his decision [Section 122 (2)] by eviction of the trespasser. So can the Municipality under Section 113 Municipal Act. If at the time of the Survey the fixing of the boundary is disputed, E. O. can decide under Sections 119 and 120 (submission to Arbitration) or the last clause of Section 120 read with the first of Section 119. Such a settlement excludes for the future any other evidence as to the location of the boundary, except in so far as the C. T. S. Records do not afford satisfactory evidence of the boundary fixed If this Manual has been followed and the C. T. S. mapping has been well done, the records will afford clear evidence. When the dispute is not as to the boundary, but as to the possession of land irrespective of the boundary, the Civil Courts have jurisdiction (R. 7859—17). Compare, I. L. R. 10 Bom. 456 with 2 Bom. L. R. 1083.

110. The E. O. will thus deal with three kinds of possible dispute, and the fourth possible kind—a dispute between Government and the Municipality—will be decided departmentally under the L. R. C. Rules, (R. 7609-86). But he may also find some land which is still agricultural, yet falling within the limits to which the C. T. S. has been extended. Such land is entirely outside his jurisdiction, and nothing can be entered in the Register, except that it is "agricultural." Disputes as to such land can be decided and a record of their decision can be made only by the Collector and his staff under the ordinary Revenue Code Rules, for the purpose of the Record of Rights, when Chapter X-A L. R. C. has been applied to the area.

111. Upon reaching a decision, E. O. will record it in the Enquiry Register; should the case be uncontested or so simple that the decision as well as its reasons can be summarised in a line or two, then the whole proceeding can be written in the Register; but when there is contention and documents

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* Thana Municipality was found in 1916 to have alienated by lease 37 strips of public road, the town being already congested; and had sanctioned buildings over spaces entrusted to them as air spaces (R. 6730—17). In R. 3386—05 Government entrusted a certain plot to Sholapur Municipality as an air space but in 1915-16 it was found almost wholly leased to private persons for building.

with the Register, and then the substance of the decision alone will be written in the Register with the note, "*see* Case Papers." When his decision has been pronounced, a notice thereof must likewise be served under L. R. C. Rules upon the land and upon the parties. For each City Survey, these notices should be separately prepared and printed, since the name and designation of the E. O. and location of his office and all that sort of thing can also be printed, and the particulars to be filled in by manuscript should be reduced to the absolute minimum of just the Survey Number, party's name, and one or two other words and figures.

112. Appeals against the decisions of E. O. lie to the Collector* only (R. 6884-15) and the power of hearing them cannot be delegated (R. 9021-17) and they must be preferred within the period of 60 days prescribed by the Code (Section 205). When an appeal has been lodged, he must wait for its decision before finally closing his Register. If he lays down his office before the decision is received, the Register will be completed by the officer who takes charge of the records.

113. Finally, E. O. will see whether his decision or the appellate order affects the map as first drawn by the Detail Measurer. He will cause the amended boundary to be inserted, and when the whole sheet is finally revised he will sign it and date it, and it will then be ready for printing and for the further steps of compiling the Property Register and issuing the Sanads. The Records he will leave will be this corrected map and the Enquiry Register and the files of individual cases. It will of course often happen that in respect of two or even a large number of properties the contention and the decision will be similar. In such cases he should adopt the usual procedure of the Courts, and having thoroughly threshed out and decided the point in one test case he should repeat the decision in a more formal and much more compressed manner in the remaining cases which it covers.

114. One other task which may be imposed upon E. O. is the classification or rough valuation of properties for the purpose of assessing the Sanad fees, *see* para. 144 below. Of course, this valuation or assessment is rough and does not require any elaborate investigation, but can be easily done by E.O. when he views the property if he has even a moderate acquaintance with the valuation of house property. It is rarely necessary to make the valuation at all close. If this task is allotted to E. O. it should be essayed from the beginning and not after the other operations have concluded, involving a fresh tour of the whole city. Its results should be given in one additional column added to the Enquiry Register.

115. It is perhaps hardly necessary to say that the E. O. must indispensably view every property and compare its boundaries as mapped with what he sees on the ground. He may even discover cases in which the mapping has not followed the boundary as he would himself place it. Any omissions to divide property between two owners or cases in which a plot of land has been included in the wrong property will thus come under review; and nothing is left solely to the judgment of the Detail Surveyor.

116. The form of the Enquiry Register should provide for the following particulars:—

The name of the Peth or Ward or tikka sheet should appear at the head, and probably it would be convenient to have a small separate volume for each sheet.

(1) The current or chalta Number of each property in the sheet.

(2) Old City Survey, or Municipal or Revenue Survey and Hissa Number.

(3) Area.

(4) Supposed name of holder as in Municipal records or otherwise.

(5) Date of service of notice (*a*) upon occupants, &c., (*b*) upon the property.

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* A special officer was appointed in R. 11260-17. It is doubtful whether Section 203, L. R. C. covers appeals under Section 50 A, Municipal Act (R. 14448-17).

(6) Who of the parties were present.

(7) Is the plan and measurement accepted and confirmed, or is it corrected?

(8) Decision as to (*a*) tenure, (*b*) rent or assessment, (*c*) when rent or assessment is to be revised, (*d*) name of holder, mortgagee in possession, lessee, other right or encumbrance-holders and attached easements.

(9) Reference to the file of Proceedings when contested.

(10) Date of service of decision order.

(11) Appeal order, if any.

(12) Final City Survey Number of the property.

(13) Classification for Sanad fees.

(14) Amount of fee fixed by Collector (with notes of any additional penalties under proviso to Section 133).

(15) Number of Receipt for collection of fee.

Column 3 will be corrected if the decision requires it.

In Column 8 when the decision is uncontested a brief note of the ground of decision and of the evidence or admission may be made without however infringing Sections 193-4; but assoon as these entries are likely to be lengthy they must be recorded upon the Proceedings File with a reference in Column 9.

117. S. L. R. will also find it convenient to prepare and print forms for E. O.'s Proceedings so that everything may be as succinct and tabular as possible, and clerical labour in writing the frame work of the Enquiries may be saved. Such Forms usually require separate printing for each city; and D. L. R.'s sanction to their printing should be got in time (G. 6259-15, 600-17 and R. 8412-17).

118. It will have been noticed that while E. O. will decide disputes as to boundaries between occupants, still he has no authority to decide a dispute as to title *when it does not affect boundaries.* For instance, the occupant A claims to be the owner of a house and ground, while B alleges that A is his mortgagee only. This dispute E. O. cannot settle under the City Survey law, but he must put down what appears to him *prima facie* to be correct. His decision, however, has no probative value and carries no presumption of correctness. But if the Record of Rights Act, Chapter X-A, L.R.C. is applied, and he is directed to compile it (as will be the usual practice) then it becomes his duty to settle such disputes as well as he can, though still in an informal way, and his decision is not final; but when he has recorded it and it is not upset by early reference to a Civil Court, then under Section 135-J, L. R. C. it acquires a *presumptive* value, so that the burden of proof is thrown upon the party who contests the correctness of the entry (*see* also R. 52—17). When such an extension has been made, the E. O. will, therefore, be required to examine the records of the Sub-Registrar and to note (when properties have been sold or mortgaged) the prices and considerations as nearly as he can ascertain them from the documents and otherwise, and he will insert a reference to the registered documents or other evidence. Here he will be required to record tenancies when they are for a period of 21 years or over (R. 685—16). Tenancies not based on a lease or document, but running by custom from year to year are not 'long' tenancies or leases, even though in fact they have lasted for generations. The owner can always terminate such a tenancy by due notice.

The Record of Rights Act has been applied (R.. 685—16) to the four cities of Ahmednagar, Barsi, Gadag and Godhra, and further to the following cities in R. 6106-17:—

Northern Division.	*Central Division.*		*Southern Division.*
Bandra.	Sholapur.	Nasik.	Belgaum.
Viramgam.	Igatpuri.	Bhusaval.	Bagalkot.
Nadiad.	Dhulia.	Poona.	Ranibennur.
Anand.	Manmad.		Byadgi (R. 1462 of 18).
Borsad.	Jalgaon.		
Thana.	Nandurbar.		

and to the city surveyed suburbs of Ahmedabad in R. 8345-17.

It is contemplated that it will generally be extended to all surveyed cities, since it affords the only satisfactory machinery for keeping the records up to date when once they have been framed, and it gives us legal power to charge fees for further sub-divisions and alterations of property boundaries which have to be mapped in the course of maintenance.

119. It has already been noted that after the completion of this Enquiry, *the numbering* (para. 84) must be finally settled. It must wait until the Enquiry is finished, because we do not know how far E. O. will amalgamate or separate properties which the Measurer took as single units.

120. While enquiring into titles as between Government and the Municipality and occupants, E. O. will necessarily ascertain what properties are held free of rent or assessment, and what properties are liable to assessment, and how much they are paying and for what period it is fixed. He will also note those occupancies which he finds to be free of such charges whether they are exempt by law or by specific grant or only by custom. He will therefore also have to determine the boundaries of the old Gaothan within which land is usually exempt from building assessment, and beyond which it is liable to altered assessment under Section 48, even though it may for a long period have inadvertently been unassessed. E. O. will not usually be directed to impose the assessments in such cases, but will submit to the Collector schedules of the different kinds of properties which he finds and suspects to be liable.

121. Under Section 100, L. R. C., the E. O. has power to assess all land not hitherto assessed and whether occupied or not occupied. But unless he is so instructed, he is not obliged to carry out this assessment, and in practice it is never done. If he were directed to make an assessment, then he would base it upon the values of land, and a precedent can be found in the case of Bijapur (R. 6515—95). If E. O. is not directed to make assessments, then all such assessments will be made by the Collector under Section 52, except in the few cities where old L. R. C. Rules 36 and 57 apply and in those which are already assessed (Bijapur). Under the proviso to this Section 52 the Collector can investigate claims to hold land upon Inam tenure. E.O. will therefore record the tenure upon which he finds land is actually now held, but will not impose assessments.

122. He will submit to the Collector schedules of unauthorized occupations where eviction seems to be required, or of lands liable to assessment or altered assessment (for an interesting case, *see* R. 5275-17). Also he should not ignore questions of easements; he may find open Government spaces upon which easements are being allowed to grow up by neglect, such as doors and windows abutting upon Government land which the house-owner is not entitled to use (*see* para 98.) The Collector should take care that when spaces are decided to belong to Government but are wholly or partly in the possession of any unauthorized persons, eviction should be promptly effected, otherwise the unauthorized possession would certainly ripen into *adverse* and known possession. Likewise encroachments on streets or other land vesting in the Municipality should be noticed and schedules sent to them for action under Section 113 (3) or 122 (2) District Municipal Act (R. 3251-17 according as the encroachment began before or after the land came within the Municipal District. Even if limitation has run for 30 years against them, still on payment of compensation they can evict; (I. L. R. 38 Bom. 15). This is little different, however, from the ordinary power of acquiring land on payment.

The Municipality has also power to deal with encroachments upon open spaces, whether they vest in them or not. To deal with these encroachments may take long, and they may ultimately be conceded and not removed (*see* para. 108). Therefore, they should be mapped as first found; when they have been removed or modified, the map can be corrected. The maintenance staff should see that the schedules are fully dealt with, if not completely disposed of, before E. O. finishes his task.

123. Sections 128 and 129 L.R.C. no longer have any operation unless we are revising a city once surveyed under Act IV of 1868. When the Collector extends a town site under Section 126 it is doubtful whether the proviso in the last clause of Section 126 would not debar him from bringing any Inam land settled under the Summary Settlement within the town site limits. If it were so brought in, then Section 134 would apply to such Inam land; in some Gujarat cities there is Summary Settlement land already within the town site to which that Section does apply. A full discussion of the liability to assessment of all the kinds of land which may be found within a City Survey and of all the incidents of its tenure, is appropriate rather to the Land Revenue Code and Rules, and commentaries thereon.

124. The original detail map must of course be available for the use of E. O. and for inspection by the public during his Enquiry, and extracts or copies thereof should be readily given when applied for, and the fee should be moderate. The ordinary L. R. C. Rules for copies of maps do not contemplate such small extracts as the copy of a single small property from the City Survey map. A special fee should be fixed for these extracts required by parties for the purpose of City Survey Enquiry disputes; probably 4 annas will be quite sufficient, in most cases, and a staff of copyists should be engaged. Frequently the main property and the portion in dispute will be (chalta) numbered as two separate plots, while the claimants will claim that they are one property (*see* para. 58). Fees for two maps should not be charged for such separate portions, and generally it should be remembered that fees to be charged for maps and copies in the C. T. S. Office should not be made into a source of revenue, which has sometimes occasioned public complaint, but should be sufficient only to meet comfortably the cost of preparing them. But great care must be taken of the original map during these operations, because it has not yet been printed, and it is an indispensable and irreplaceable Record which must not be handled by unauthorized persons, and when taken into the street, must be pinned on a board and covered with a cloth to keep it reasonably clean and dry.

125. We must also not forget that in some cities there is old Cantonment land and the tenure thereof is special, and not governed by the L. R. C., and care should be taken not to do anything which would have the effect of altering this tenure without proper authority from Government. Such old Cantonments are found in Dharwar, Sholapur, Surat, Satara, Kaira, and numerous other places (*see* R. 8891-09, para. 8).

126. The upshot of all this is that in the Enquiry and Property Registers E. O. will have to record numerous possible tenures. They will not all be the same in every town. Some kinds exist in one place, but not in another. It will therefore be best for E. O. to make out a list of all the kinds of tenure which he encounters; for all those which are sufficiently common to make it worthwhile he should apply an abbreviation such as a capital letter of the alphabet, and instead of writing out the particulars of the tenure every time in the Register he should simply insert this capital letter. Some such list as the following is suggested:—

A=Revenue-free by custom.

B=Paying rent under lease from Government.

C=Paying (altered) assessment to Government on Land Revenue Code tenure.

D=Lands sold outright by Municipality, (but liable to pay Land Revenue).

E=Lands leased by the Municipality upon rent fixed for a period.

F=Lands held by Municipality for public and non-profitable purposes.

127. There may be several other common tenures, and again there may be some kinds of which only one or two examples are found in the city. For this last kind no abbreviation is necessary. When the whole Enquiry is finished and appeals decided, it may be found that some of these kinds disappear. But after final revision, the list being printed or engrossed at the outset of the Property Register can be used for expressing briefly the nature of the

tenures found. When E. O. has prepared this list and before his Enquiry is completed, he should submit it for scrutiny to the Director of Land Records and the Collector, in order that prompt attention may be given to any peculiar or dubitable tenures that are alleged to exist. Such doubts ought to be resolved and properly decided by superior authority before the E. O.'s proceedings are finally closed.

128. This raises perhaps another question whether the E. O. can revise or modify his own decisions when once recorded, or must he leave all such revision to the appellate authority? It would seem that like all other Courts he might certainly correct a mistake or misapprehension, provided only that he issues fresh notice of his revised decision to the parties concerned. But if he proposes to make an amendment which is disputed or contentious, then it would be better to refer the parties to the Appellate Court in case of disputes under Section 50-A (or 37, L.R.C.) when the proceedings are formal. But in other matters such as entries of the nature of title which are not in dispute with Government or the Municipality but are entries under the Record of Rights (if applied) or the informal Settlement Registers under Section 108, it would seem that he may correct his entry at any time, provided he makes the correction perfectly clear and initials and dates it, (*cf.* R. 8720-91).

129. The present standard rate for Enquiry is about 25 properties per working day. Of these not all will be disputed; probably not even 5 of them. But the average output is to cover all cases. It may happen in some towns that disputes are more numerous and keenly contested than in others. If a full Record of Rights (para. 116) is being prepared, the scale would be lowered to allow for searches for prices paid, &c., and an extra clerk may be needed for reading documents and summarising their contents. Therefore, it would follow that one Enquiry Officer can keep level with the work of about five Detail Surveyors. If there are a larger number of Surveyors, then he could never catch them up, and therefore he may safely commence his enquiry as soon as even a part of the first sheet is completed; and his enquiry will not be finished when the detail mapping ends. He will retain one Surveyor at least after the rest of the staff has been disbanded. He will keep a diary of the number of properties enquired into, the number disputed and the number in which the original map or record required to be corrected, and also note the percentage result of appeals.

District Municipal Act III of 1901.

For ready reference, the sections which bear upon Enquiry work are here reprinted :—

3 (7)—"Building" shall include any hut, shed, or other enclosure, whether used as a human dwelling or otherwise, and shall include also walls, verandahs, fixed platforms, plinths, doorsteps, and the like.

3 (12)—"Street" shall mean any road, footway, square, court, alley or passage, accessible whether permanently or temporarily to the public, whether a thoroughfare or not; and shall include every vacant space, notwithstanding that it may be private property, and partly or wholly obstructed by any gate, post, chain or other barrier, if houses, shops or other buildings abut thereon, and if it is used by any persons as a means of access to or from any public place or thoroughfare, whether such persons be occupiers of such buildings or not, but shall not include any part of such space which the occupier of any such building has a right at all hours to prevent all other persons from using as aforesaid.

3 (13)—"Public street" shall mean any street—

(*a*) over which the public have a right of way, or

(*b*) heretofore levelled, paved, metalled, channelled, sewered or repaired out of Municipal or other public funds, or

(*c*) which under the provisions of Section 90 is declared by the Municipality to be, or under any other provisions of this Act becomes, a public street.

4 (4)—When any local area ceases to be a municipal district, the Municipality constituted therein shall cease to exist, and the property..... vested in any such Municipality shall, subject to all charges and liabilities affecting the same, vest in His Majesty,.....

40 (1)—Every Municipality shall be competent, subject to the restriction contained in sub-section (2), to lease, sell or otherwise transfer any ..... immovable property which may, for the purposes of this Act, have become vested in or been acquired by them,.....

40 (2)—In the case of every lease of immovable property for a term exceeding seven years, and of every sale or other transfer of any such property, the previous sanction of the Commissioner is required.

40 (3)—In the case—

(*a*) of a lease for a period exceeding one year, or of a sale or other transfer, or contract for the purchase, of any immovable property..... .....the sanction of the Municipality by a resolution passed at a general meeting is required.

48 (1)—Every Municipality may from time to time ....make .....bye-laws, but not so as to render them inconsistent with this Act,.....

(*n*) regulating the conditions on which permission may be given for the temporary occupation of, or the erection of temporary structures on public streets or for projections over public streets, ...

(*o*) for preventing the erection of buildings without adequate provision being made for the laying out and location of streets;

(*p*) for ensuring the adequate ventilation of buildings by the provision and maintenance of sufficient open space either internal or external and of doors and windows and other means for securing a free circulation of air ;

50 (1)—Every Municipality may acquire and hold property both movable and immovable, whether within or without the limits of the Municipal District.

50 (2)—All property of the nature hereinafter in this section specified, and not being specially reserved by the Governor in Council, shall be vested in and belong to the Municipality, and shall, together with all other property, of what nature or kind soever, not being specially reserved by the Governor in Council, which may become vested in the Municipality, be under their direction, management and control, and shall be held and applied by them as trustees, subject to the provisions and for the purposes of this Act ; that is to say :—

(*a*) All public town-walls, gates, markets, slaughter-houses, manure and night-soil depots, and public buildings of every description.

(*b*) All public streams, tanks, reservoirs, cisterns, wells, springs, aqueducts, conduits, tunnels, pipes, pumps and other water-works, and all bridges, buildings, engines, works, materials and things connected therewith or appertaining thereto, and also any adjacent land (not being private property) appertaining to any public tank or well.

(*c*) All public sewers, drains, tunnels, culverts, gutters and watercourses in, alongside, or under any street, and all works, materials and things appertaining thereto,... ....

(*e*) All lands transferred to them by the Secretary of State for India in Council, or by gift or otherwise, for local public purposes.

(*f*) All public streets, and the pavements, stones and other materials thereof, and also all trees, erections, materials, implements and things provided for such streets.

54 (1)—It shall be the duty of every Municipality to make reasonable provision for the following matters within the Municipal District under their authority, namely :—

(*f*) removing obstructions and projections in public streets or places, and in spaces not being private property, which are open to the enjoyment of the public, whether such spaces are vested in the Municipality or belong to His Majesty ;

(*i*) constructing, altering and maintaining public streets, culverts, Municipal boundary-marks,.....

(*k*) naming streets and numbering houses ;

90 (1)—It shall be lawful for the Municipality to lay out and make new public streets, and to construct tunnels and other works subsidiary to the same and to widen, open, enlarge, or otherwise improve any such streets (and to turn, divert, discontinue or stop up any such streets) and, subject to the provisions of sub-sections (2) of Section 40, to sell any such land, heretofore used or acquired by the Municipality for the purposes of such streets, as may not be required for any public street or for any other purposes of this Act.

90 (2) - In laying out or making, or in turning, diverting, widening, opening, enlarging, or otherwise improving any public street, in addition to the land required for the carriage-way and foot-ways and drains thereof, the Municipality may purchase the land necessary for the houses and buildings to form the said street, and subject to the provision contained in sub-section (2) of Section 40, may sell and dispose of the same in perpetuity or on lease for a term of years, with such stipulations as to the class and description of houses or buildings to be erected thereon as they may think fit.

90 (3)—When the Municipality consider that in any street, not being a public street, or in any part of such street, within the Municipal District, it is necessary for the public health, convenience or safety that any work should be done for the levelling, paving, metalling, flagging, channelling, draining, lighting or cleaning thereof, the Municipality may by written notice require the respective owners of the lands or buildings fronting, adjoining or abutting upon such street or part thereof, to carry out such work in a manner and within a time to be specified in such notice.

90 (4)—After such work has been carried out by such owners *or, as provided in Section 156, by the Municipality* at the expense of such owners, the street or part thereof in which such work has been done may, and on the joint requisition of a majority of the said owners shall, be declared by a public notice, put up therein by the Municipality, to be a public street.

90 (5)—A Municipality may, at any time, by notice fixed up in any street or part of a street not maintainable by the Municipality, give intimation of their intention to declare the same a public street, and unless within one month next after such notice has been so put up, the owner or the majority of several owners of such street or such part of a street lodges or lodge objections thereto at the Municipal office, the Municipality may, by notice in writing put up in such street, or such part, declare the same to be a public street.

Sections 92, 93, 94 provide for improving public streets by the acquisition of open spaces, doorsteps, and projections ; or by setforward to the regular line over any intervening open space.

113 (3)—The Municipality may, by written notice, require the owner or occupier of any building to remove or alter any projection, encroachment or obstruction which, whether erected before or after the site of such building became part of a Municipal District, shall have been erected or placed against or in front of such building, and which

(*a*) overhangs or juts into, or in any way projects or encroaches upon, any public street, so as to be an obstruction to safe and convenient passage along such street, or which

(*b*) projects and encroaches into or upon any uncovered aqueduct, drain or sewer in such street, so as to obstruct or interfere with such aqueduct, drain or sewer, or the proper working thereof :

Provided always that the Municipality shall, if such projection, encroachment or obstruction shall have been made in any place before the date on which such place became part of a Municipal District, or after such date with the written permission of the Municipality, make reasonable compensation to every person who suffers damage by such removal or alteration ;.....

122 (1)—Whoever in any place after it has become a Municipal District, shall have built or set up, or shall build or set up, any wall or any fence, rail,

post, stall, verandah, platform, plinth, step, or any projecting structure or thing, or other encroachment or obstruction, in any public street, shall be punished with fine which may extend to twenty-five rupees.

(2)—The Municipality shall have power to remove any such encroachment....., and shall have the like power to remove any unauthorised encroachment of the like nature in any open space not being private property, whether such space is vested in the Municipality or not, provided and that if the space be vested in His Majesty the permission of the Collector shall have first been obtained, and the expense of such removal shall be paid by the person who has caused the said.....encroachment.....

Note.—For process fees in formal or summary enquiries (at 3 as. for a summons, and 6 as. for a warrant, and bhatta as for Courts of Small Causes) *see* p. 687 B. G. G. of 8-7-75. The 'Court' can order the costs to be borne by either party (R. 4468-82).

CHAPTER VI.

Map Printing.

130. When the enquiry is finished for any particular sheet and when the final numbering has been carried out, we can then proceed to print the maps. The process to be employed is the Vandyke, by which a tracing made upon paper reasonably transparent (not necessarily tracing cloth but Bank Post or other thin white paper will do even better) is laid upon zinc sheets specially prepared in such a way that the tracing is transferred by the action of light to the prepared printing surface. In this way there can be no variation whatever between the tracing and the printed map, as may occur in photographic re-production upon gelatine plates. It is essential that the ink used in the tracing must be uniformly and adequately opaque, such as Higgins' Waterproof Indian Ink, perfectly evenly and uniformly applied. Common ink will not do, because the lines are sometimes dense and sometimes almost transparent. Moreover, since after printing the tikka sheets at their original size we require to reduce them by photography to a general map of the city, it is necessary therefore that the lines and figures used in the first tracing should be large enough and thick enough to be still legible when photographed down. If the tikka maps are at 25 feet and we reduce to 200 feet to the inch, this is a reduction to $\frac{1}{8}$th, and in fact 64 sheets at 25 feet to the inch will reduce to one sheet of the same size at 200 feet to the inch. If therefore we write figures on the first tracing of such size that when reduced to $\frac{1}{8}$th they are invisible or illegible, this will not do. In Fig. XXIV, we find a schedule of figures and letters and lines and hatchings as they should be drawn in 25 feet and 40 feet tracings, in order that they may be properly legible when photographed down to 200 feet. In order to secure proper and uniform thickness of lines and size of figures and good density of ink, it is expedient that these tracings should be made under the supervision of the Photozincographic Office in Poona. They could be made locally, provided the above requirements can be guaranteed, but experience showed that local tracing is very risky and often had to be done again. We are now sending local men to be trained in Poona. For tracing, one must have an absolutely rigid frame so arranged that the light passes from underneath; and for this reason cloth mounted originals are inconvenient; and the work must always be done neatly and uniformly, so that it may not look unsightly when printed. In tracing, the built and unbuilt portions of each property will be distinguished by hatching the built portion. The lines will be drawn far apart so as not to coalesce upon photographic reduction. Hand printing stamps can be obtained for printing names though they might need retouching by hand.

131. We have to print not only boundaries of properties but also their numbers as finally numbered, and the storeys and the names of streets, and names of public buildings, Government and other offices, cattle-pounds, and so on. Municipal, Gaothan, and Village boundaries will be shown by distinctive lines. Tramways and Railways will be shown by conventional symbols, and various other such particulars as may be decided for any particular town such as the location of the water and drainage mains, reservoirs, and public wells, and so on. Important Temples, Markets, Schools, Hospitals (ordinary or infectious), Mills or Factories employing numerous hands, Banks, will also be mentioned. We may also make a few distinctions between ordinary properties and Inam Survey numbers, and Municipal lands (*see* Commissioner N. D'.s C. T. S. No. 27, dated 11th March 1916), though it is usually better to leave these details to be dealt with as subsequently described in para. 134 below.

132. When the sheet has been completely traced and all the names and numbers as above properly inserted, it will be printed off. Of course, there will be a printed title and the scale, year of Survey, and an explanatory list of symbols employed will also be printed on the face if there is room or, if not, *on the reverse.* The LL lines will not be traced across the map since they would tend to confusion, nor will any off-sets, or the base lines or traverse legs be

drawn, nor any dimensions which the surveyor may have recorded, but it is indispensable and most important that the exact position of every Theodolite station should be traced and the station numbered, and round the margin of the map *the extremities* of the LL lines should be marked and numbered, so that if desired they could be drawn in pencil across the map with a ruler.

133. When printed, the next thing is to join all these tikka maps into the general map of 200 feet. Here we shall find the LL lines very useful as a guide. Round the margins of the maps there will frequently be pieces of properties or whole properties which appear in both maps (*see* para. 66). The first step will be to place together on the floor of a large room or on the large boards available in the Photozincographic Office as many printed map-sheets as will photograph down to one plate on the camera. They will be trimmed down with the scissors, and overlapping portions cut away, and the junction will be made by means of the LL lines; and when it is completely effected the whole block of maps will then again be examined by a draftsman and improved for final photography. The steps required will be to remove duplicate street names; for instance, when the same name appears in both maps it would be sometimes better replaced by a single name, one of them being blocked out. Then Ward or Peth names which could not conveniently be shown upon single sheets can now be inserted over blocks in large letters. Also natural feature, such as hills, rivers, and parks with trees may be touched up by shading or contour lines. On the exterior sheets the numbering of the LL lines at the extremity of every tenth (in a 1/5th reduction) or every sixteenth (in a 1/8th reduction) should be retained and the rest cut off. When this is completed, the photographic reduction is made and the resulting negatives are joined together into the general wall map at 200 feet.

There must be some distortion in this process since the gelatine negatives are liable to shrink or stretch in transfer to the printing stones [we hope to do this work soon by the finer Helio process instead of litho, a specimen of a Helio reduction to 200 ft. from a village site survey is given in Figure XXIV(*a*)]. Therefore, a photographically reduced map should not be used in arguments about exact distances. Its purpose is to show the general collocation of the City with ample accuracy for topographical purposes. Encroachments and other disputes must be decided by the printed tikka sheets, or originals thereof.

The largest camera in use in Poona gives a plate 20″ × 24″: taking Tikka sheets at 24″ × 30″ [*see* para. 51, the extra 2 inches (para. 66) disappear at the tracing stage]; this means that at 40 feet to one inch 16 sheets and at 25 feet to one inch 40 sheets of original size 24″ × 30″ will photograph into one *plate* at 200 feet to one inch.

134. But there are certain features desirable for administrative purposes which we cannot conveniently show upon the first tracings and printed tikka sheets. The Municipality will like to know what lands are absolutely Municipal property and what are held by them free of rent, and what are subject to rent. Also they would like to know the location of latrines, water stand-pipes, dust bins, pail and kachra depots, slaughter houses, Municipal schools, toll and octroi offices, and so on. We could not have printed all these things by different symbols on to the original map without overcrowding and confusing it. But the Municipality can now take a printed set of tikka sheets (or a final 200′ wall map) and can color them with various color washes upon all these kinds of properties and localities which they desire to distinguish; particularly the locations assigned to dangerous and offensive trades (Section 151-D, Municipal Act) and all burial and burning grounds. Just so the Drainage and Water Works Engineer can draw or paint his drainage and water pipes, out-falls, and all other particulars in the exact position they occupy. Then the Collector can take another set and can color Government lands granted on lease or paying altered assessment, or Inam lands, or temporary leases, or lands unoccupied and available for sale. The Police and the Excise Administration can also take sets and color them according to their requirements; at Census time another set may be used for the control of the Census operations. Obviously, if we printed all these details even on the tikka maps they would become unduly congested, and, when photographed down, the general 200 feet map would become entirely illegible.

134-A *Contouriag*—One of the most important things which the Sanitary, Water, or Roads Engineer requires to know about a city is its contouring or distribution of levels A contour means that line running through a city along the ground surface which is everywhere at the same level. In a hilly town the contouring would naturally form rings round each hill and would show deep indentations whenever they cross a natural drainage, stream or river. In a very flat city like Poona, there would probably be only a very few contour lines altogether and these mostly along the banks of the river, if we drew each line at an interval of 5 ft. In Nasik there would be a considerable number of lines even at 10 ft. of vertical interval.

In open country a contour line can be followed by a Surveyor throughout its course. In a city this is obviously impossible, as it would run through houses and walls. The only possible course is to follow the principal streets and mark the levels along them and determine where the contour lines cross each street. We have not discussed levelling in this Manual as part of the City Survey operation, and hitherto in Bombay levelling has never formed part of City Survey. There is no doubt it ought to be included. As soon as the printed sheets are available, a levelling Surveyor should take a set of sheets and should determine first the highest point and the lowest in the city so far as he can judge, and should select a solid and good bench mark as a Datum or starting point for levelling. Taking this Datum at nearly the lowest level in the Town area, he should call it 100 ft. Then all other levels above it will be expressed by figures from which by deducting *100* we get the height above Bench Mark. Even levels below it (which may be reached in drainage, excavation, or well sinking) will still be positive, and not *minus* levels which are objectionable. He should then determine whether contour lines should be put in at intervals of 5 or 10 feet. In very flat towns 5 ft. would probably do. In very steep hilly towns, 10 ft. He should then take levels starting from Datum along the Theodolite legs which traverse the principal streets, and determine where the contour lines cut them. Also he should follow up the beds or courses of the most conspicuous drainage lines such as rivers or nallas, and find where the contour lines cross the water level. Also he should work several lines up the sides of the principal hills. Then he will have to join these contour lines across through the houses according to his judgment and by inspection of the ground. The object of this contouring is not to get exact levels of every fraction of the city, but to give bold and yet not recklessly inaccurate contours which will assist the Engineers of the future in fixing pipe lines, new roads, tramways, and so on. He ought to be able to mark on the maps with exactness in the main streets precisely where the contours cut the Theodolite legs; and if he does this accurately even for 50 Stations in the city, he will have saved much future labor by providing starting points for local levelling. When great accuracy is desired, future levellers should take off from points not exposed to alteration from road repairs The bench mark must be carefully recorded and preserved and included in the inspections of Theodolite Stations and when it is possible to connect it with any other more important levelling Datum, this may also be done. It ought not to take a competent leveller more than a month to complete a good contour survey of quite a considerable city, when he is provided with the maps contemplated by this Manual.

CHAPTER VII.

Property Register.

135. Upon the conclusion of the enquiry and the appeals, and after assigning the final numbers we then proceed to write up the Property Register during the printing of the maps. The Property Register is a summation of the results recorded in the Enquiry Register. We can, therefore, leave out all the dates of notices and notes about persons present and reasons for decision, &c., which are in that Register. Moreover, we have now given the properties a final number and first we should make a sort of index showing the connexion between the final Number and the Chalta or current Number which the Measurer used in his sheets, and which was followed by the Enquiry Register. Then we should prepare the Property Register in the sequence of the new final Numbers and in volumes corresponding to the wards, or parts of wards if they are very large. The Form of the Property Register will be as shown on page 58. When it is completed, the areas will be totalled, each kind of tenure which it is necessary to record separately in the Village Tharavband (V.F. V.) being separately totalled, with the revenue if any which accrues. Commuted revenue will be dealt with as described in the Manual of Revenue Accounts. When transferring total areas to V. F. V, take the nearest gunta and quarters.

Whenever any change in area or revenue occurs in the Property Register, these totals must be corrected, just as the Abstract of V. F. I in ordinary villages is kept up to date and correct by the Village Accountant. No 'Kam-Jasti Patraks' from the District Survey Office are needed, since the City Survey Office is self-contained and can make all its corrections, quoting of course the authority.

Property Register, City of

Survey number or sub-division. 1	Old No. (Revenue, Municipal or City Survey.) 2	Tenure (for abbreviation *see* Schedule on first page). 3	Area in sq. yards. 4	Assessment. 5	Special rent. 6	Year in which assessment is liable to revision or lease expires. 7	Owner's name. 8	Nature and origin of title. 9	Name of Lessee and details of title. 10	Mortgagee with possession and details of title. 11	Other rights. 12	Date of mutation and reference to authority. 13	Remarks. 14

Instructions for writing up the Property Register.

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1. Column 5 should never be left blank, the word nil or 'muafi' being written when no assessment is recovered.

2. Column 5 will show the assessment fixed and sanctioned under chapter VIII, Land Revenue Code. When there are separate rents under leases or Sanads granting permanent occupancy given prior to the City Survey Settlement these will be shown in Column 6.

3. Column 7 will show the year of expiry of the general Settlements except when there are special leases shown in Column 6. It will then give the year of the expiry of those leases.

4. In the case of Government land not given out on permanent tenure, Column 8 will remain blank, unless the land is reserved for a special purpose, when the details can be given in this column.

5. Column 10 will contain the names of lessees of Government land who have no permanent right of occupation. In such cases Column 8 is blank. The date of expiry of the lease will be given in this column and not in Column 7.

[Where a Record of Rights is being introduced this column will also contain the names and terms of lease of long term lessees under permanent occupants.]

6. Column 12 will be filled in when the register is to be used as a Record of Rights under Chapter X-A, Land Revenue Code. It will contain such rights as are recorded in the similar column of Village Form VI. Also notes of easements found by the E. O. will go here.

7. A mortgagee of a building belonging to a permanent lessee of the soil will be shown in Column 11 against the name of his mortgagor in Column 10.

8. Mutations will be made direct in ink into this register, *see* Chapter on Maintenance. Original entries must therefore be given plenty of room, leaving from half to one inch between entries (*see* para. 151).

9. When on any page so many corrections have been made as to crowd the entries, the page (*i.e.*, only the last correct entries) will be recopied and kept in a portfolio; when the whole Register requires re-writing, all the remaining pages will be similarly recopied and bound up. Subsequent alterations will be made upon the new copy.

10. When one or more upper floors or parts thereof are held by separate owners, though not building sites, they may be entered parenthetically below the ground floor property as sub-numbers, for Municipal and other purposes, noting in Column 12 that they have the right of standing over the lower floor properties; so too with houses built on bridges or on projections over a street, &c.

CHAPTER VIII.

Sanads.

136. Sanads are to be issued after the Property Register has been written and the maps printed. The printed maps show the final numbers and we take about four copies of each sheet and cut them up so as to get one map of each property cut out with enough of the surrounding properties to indicate the boundaries and surroundings. Then upon a Sanad Form we paste the map of the Survey No. and then finally we take care that the whole sequence is complete according to the Property Register volume. Then we write in the name of the holder and the tenure as in the Property Register, and then we may write down some, though not all, of the dimensions as shown on the original detail map sheets. A scale strip is to be printed on the Sanad, so that any other dimension can readily be ascertained by anyone who knows how to use a scale. Then the Sanads must be signed by the special officer appointed for this purpose by the Local Government (R. 341—16). Of course the Sanad will show for what city and ward and on what date it is issued, and so on. It is not often possible for the E. O. himself to sign the Sanads since he cannot remain at his post idle while the maps are printed, and Property Registers and Sanads are drawn up; but if he can sign any, then so long as he is discharging his functions of E. O., or even afterwards if he is available, he is the proper person to sign (R. 8032, 8479-17); if he is not available, another officer must be appointed (R. 3984-17). There are two Standard Forms (R. 12163-14), but it must be very distinctly understood that these are only specimen Forms and that the Sanad does not create, modify, or take away any title or tenure, but leaves things exactly as they were actually found by E. O. The wording of the Sanad must be altered to fit the exact facts of each case. (R. 10347—09, 482—10, 5000 - 16). The Standard Forms provide for properties held revenue-free, and properties paying revenue, but as we have already seen there are half a dozen or more tenures besides these which must be recognised and confirmed by the Sanads, and not altered (R. 5000-16). For Inam lands held already under Sanads, the new City Survey Sanad will simply recite the fact, and give the dimensions.

Formula (1) Dextrine Pastes—

White Dextrine	...10 ozs.
Water	...10 „ (Fluid).
Formalin	...15 minims
or	
Salicylic acid	...15 grains.

Rub the Dextrine down to a smooth paste with a little water, add the remaining water and heat in a water-bath* until dissolved, stirring well, during heating, in one direction only. Add the formalin or Salicylic acid. Allow to set. Should form a white mass free from lumps.

Formula (2) Flour Paste—

White Flour	...4 ozs.
Arrowroot	...1 oz.
Salicylic acid	...60 grains.
Water	...20 ozs.

Rub the flour into a cream with a little water, add to the remainder, and boil in a water-bath* for 10 minutes.

2. Dextrine, Formalin, and Salicylic acid can be had from any well known druggist. Paste thus made will keep well and will protect the adhesions from attacks of cockroaches or other insects, or growth of mildew.

137. When the Sanads have been drawn up, they must of course be checked and compared by another official besides the writer, and initialled by him, and then they will be signed by the specially appointed officer (*see* para. 136) after such tests as he deems proper. Then the Collector will issue notices under Section 132, and the fees fixed will be posted in the Enquiry Register (with addition of penalties for taking delivery after the prescribed time). There will also be needed a combined Day and Receipt Book similar to V. F. IX, but simpler, for the use of the collecting staff, which will be specially printed for the

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* A large dekchi containing water and placed over a fire to boil with a smaller dekchi containing the materials for the paste standing or floating in it.

city. Each counterfoil being specially numbered will show on its face the C. T. S. Nos., the date, and the amount of fees for which Sanads are given to one person at one time. His signature in token of receipt will be taken on the back; finally the Receipt No. will be noted in the Enquiry Register (*see* para. 116). It will be convenient towards the close of the collection operations to make an exact list of the S. Numbers for which fees are not yet collected—and some of these may ultimately have to be written off, though recoverable as arrears of L. R. (Section 132, L. R. C.).

138. The next question is to whom should the Sanad be given and how many Sanads are to be issued upon the basis of the Property Register entries. The law, Section 132, L.R.C., requires that the Sanads should be given to the holder of each "building site" and a separate fee (therefore a separate Sanad) for each such site "separately held": Now it seems clear that the word "Holder" must be taken to mean the highest holder where there are more than one. The L. R. C. defines "Holder" as including a tenant. But one could not give the Sanad to the tenant and leave the owner out. We must interpret this to mean Superior Holder. But the words "separately held" need not be so interpreted. Here separate tenancies can certainly be distinguished. A building is included in the term land, but could not be called "a building *site.*" So if a building site belongs to A, but the building upon it is the Property of B, it is clear that A alone can receive the Sanad and still more when A owns the land and part of the building, but B owns another part of the building (such as the upper floor) without owning any of the land. But if A holds a plot of land divided into portions each of which are let to separate tenants whether on a long or short lease, or even small houses leased upon monthly tenancies, even so each such separate building site, with the house upon it, being differently tenanted is 'separately held' and requires a separate Sanad (R. 6416—09, 5000-16). But in the case of a chawl where only the rooms are let to separate tenants, it is not the building site which is separately held but only parts of the building, and here the Sanad will not be divided. Where there are co-sharers, R. 4180—83 allows duplicates, executed as originals, in favor of each co-sharer; apparently each such co-sharer would be equally liable to pay the full fee; no provision has been made for dividing the fee but a simple copying fee of not more than 8 as. for such duplicates would ordinarily be reasonable. We could hardly afford to cut up more maps for a few such duplicates. The map should be hand-copied and Re. 1 would be a fair charge or more in some cases. A mortgagee in possession is certainly a holder, but he is not the Superior Holder, and the Sanad must be made out in the name of the mortgagor, though it may be delivered to the mortgagee as his representative, if the mortgagor himself does not come forward to take delivery or pay the fee.

139. Many properties consist of what may be called a main block and some extension or other part which is not held upon the same tenure. The most ordinary case is when the main property is old Gaothan land held by custom free of revenue, while the extension is a piece of the street or some open space encroached upon or occupied at a known date and for which a rent is paid or which is admitted to be liable to revenue when Government demand it. In such cases the tenures are different ('separately held') and separate Sanads must be issued. It may seem that for such small properties, sometimes consisting only of a platform or a flight of steps, it is not worth issuing Sanads, and it is extravagant to charge a separate Sanad fee. Yet we may remember that it is not so much the main properties which cause trouble, litigation, disputes, and annoyance to the general public, but it is precisely these smal projections and excrescences which are the chief cause of City Survey operations. Where the land has been rented (*see* para. 95) by the Municipality that body must pay the fee. It is not a hardship, because they derive revenue from the land and as remarked by the Hon'ble Mr. Curtis in No. 268-S. S. of 28th April 1910 it would be a poor kindness to the Municipality to neglect to give Sanads confirming its title to all these pieces of land only on the ground that they were not large pieces; because it is precisely these pieces which are a continual nuisance to Municipalities.

140. Sometimes these excrescences are not even leased as land but exist only as easements or licenses when the person in enjoyment has executed a

Nadàva Kabulayat (no-suit agreement) admitting complete absence of ownership and agreeing to pay an annual fee for the permission to use, or perhaps enjoying the use free, but disclaiming any title (*see* para. 99). Here we have to deal with an easement and not with a 'building site' held by anybody. It would appear that for these the land over which the easement is enjoyed should be excluded from the limits of the dominant property (*vide* para. 97). But upon the Sanad for the main property it should be remarked "together with the easement of a balcony over, or a right of way (or doorsteps or platform or window) opening upon the land to the east (north, south, or west) as indicated in the plan." It might sometimes be necessary to color the plan to make it explicit.

141. If a piece of Government land is purchased revenue-free in perpetuity under Rule 9, L. R. C., while the main holding is also by custom exempt, then it is intended that the purchased piece should be always held upon the same tenure as the main property. If that main property is hereafter by law assessed, then the addition will also be assessed, and therefore there is no necessity of giving separate Sanads, but the whole will be treated as one property in accordance with the intentions of Rule 9. Likewise it may happen that in one property there are two classes of land, *e.g.*, some sold out of the street, some Inam, some originally agricultural held on altered assessment; but it may not be possible to determine the exact areas or the boundary between each portion. Here the Sanad must recite the facts as ascertained, but the whole must be mapped and numbered as one property.

142. *Government, Municipal, and Railway Lands.*—No Sanads are issued or fees charged for public buildings or spaces or for Government property, since there is no object in Government paying fees to itself. But the amount due for Government plots is assessed and deducted from the total cost by writing off part of the advance, so that no charge falls on other owners (R. 15407-17). Land held for Municipal purposes is usually free of revenue; it is not however exempted from Sanad *fees*, and Sanads should be given for each separate plot. But when this land is leased or granted on rent by the Municipality, or even when the rental has been capitalised by sale in perpetuity (*e.g.*, as at Jalgāon), Sanad fees are chargeable to the "holder." If the Municipality has parted with all its rights, then the sub-holder would be the proper person to receive the Sanad and pay the fee, and we are not obliged to have recourse to the Superior Holder. But if it is leased for a term only, or if the Municipality is receiving rent, then Sanads should be issued to the Municipality and fees charged for each separate occupancy. Land held by the Municipality from Government upon short lease (with or without rent) is Government land, and no Sanad need be issued. The terms will be in the Property Register.

143. Railway lands if held by a State Railway rank as Government lands. If the Company working a State Railway has an interest in surplus profits (G. I. P., B. B. & C. I., N. W. and other Railways) then the fees will come out of profits and will be partly, therefore, paid by Government. But if held by a private Company (Barsi), then they seem liable under the Code to pay fees for each separate plot. Government have, however, ruled in R 5109-17 that Sanads need not be issued, nor fees charged even to private Railway Companies. Buildings occupied as goods-shed or engineshed would not be separately held, nor would dwelling quarters of Station Masters or gangmen who are Railway servants. But if any house is let for a rent to any tenant, then it is "separately held" according to the arguments above used. It is doubtful whether the City Survey need in all cases be extended to land occupied by a Railway Administration. They often have excellent detailed maps of the buildings, &c., and questions of encroachment and public street, &c., do not arise inside their land. This should be considered by the Collector in fixing the C. T. S. limit under Section 126; and if the Railway carries on its own sanitary, &c., organisation and is outside the objects of a City Survey, money need not be wasted on this area, for which Sanad fees are not recoverable. Details may be obtained for the general City map from the Railway Engineers; and the Collector would be using a right discretion in excluding such an area from a 'town site' under Section 126.

CHAPTER IX.

Fee Calculation.

144. The Collector will calculate the fees thus :—

Expenditure.—First the net cost must be ascertained after agreeing the Treasury with the departmental figures and crediting against the expenditure all surplus recoveries for copies or other fees. If any further expenditure on map printing or Sanad writing is possible, this must also be calculated and included. Then he must calculate the *recoveries*. After excluding the Govt. properties for which no fee can be charged (para. 142), he must have regard to the area shown in the Enquiry Register and the value as estimated in Column 13 of that Register. For each site whether it contains a building or not, the E. O. can estimate its gross value in round thousands of rupees. The Municipal assessments might help him, but extreme accuracy is not important. The position is an element of value, and does not require separate consideration. Having ascertained for each site its value and area, these elements may be reduced to units. The unit of area may be each whole or part of 100 square yards, neglecting fractions of 100 square yards if the area exceeds 200 square yards. Then units of value may be fixed on a sliding scale such as one unit for the first Rs. 1,000 or part of Rs. 1,000, another unit for the next Rs. 2,000 ; another for the next Rs. 3,000, and so on. Thus a building valued with its land at Rs. 1,500 gives two units of value, but one valued at Rs. 7,200 would give four units. Then by multiplying the value units by the area units we get the total units of assessment for each site, and consequently the total units for the whole of the town or city area. We can then see what fee per unit is required to cover the total cost. If in many cases the fee so calculated on individual sites exceeds Rs. 10 the unit-charge will have to be slightly raised to meet the loss from the application of this limit. The Collector should aim in the first place at a trifling surplus, since some fees are sure to prove irrecoverable ; on the other hand, penalties under Section 133 will increase the recoveries ; though sometimes where the Sanads have been delivered and fees collected by the Revenue establishment these penalties have been appropriated as Land Revenue, and not as income of the City Survey. If there is a final deficit after collecting all possible fees, or if the cost per Sanad is deemed to be too high and Government agree to bear any portion of the total cost, then Government can write off any deficit shown by the City Survey account (*see* the Godhra case, R. 11155—16). The larger the number of properties, the less the average fee will be. It is hoped that under the system in this Manual the average cost per property will in time be worked down to about one rupee.

CHAPTER X.

Maintenance.

[The system of maintenance described in paras. 145-169 has been approved by Government in R. 6106-17.]

145. If we do not carefully and thoroughly maintain a City Survey after its completion it is scarcely worth the trouble of making the Survey at all. Very many City Surveys have been made in the past and have gradually decayed and become useless, and have had to be done again for want of any Maintenance system. When a Survey becomes utterly out of date and inaccurate in every detail, it of course fails to satisfy the requirements which justify such a Survey. Surat was surveyed in 1816 and again in 1867-75 and now stands in need of complete Revision. Hubli first surveyed in 1827 and again in 1875-80 is in the same predicament. Bijapur surveyed as recently as 1892 within 25 years is in need either of extensive Revision or complete re-Survey.

146. On completion of the survey and the Enquiry, the records will be handed over to the charge of the Collector or such officer as may be appointed to receive them.

The *Old* Records are of two kinds: (*a*) general, old orders and papers leading up to the Survey or describing the history and tenures, &c., and papers of any former survey; (*b*) individual, cases about particular lands, leases, encroachments, acquisitions, &c., which are found in the Records of Government by E. O. Class (*b*) will be placed in the Self-Indexing Files (to be described hereafter). Many records of class (*b*) are in the hands of the Municipality which does not always hand them over to the C. T. S. office, but should be requested to arrange them in similar files. Also maps, tippans, &c., of the Revenue S. N. which fall into the C. T. S. area should be handed over in original (or copies if the books cannot be broken up). Class (*a*) must be sorted, and ordinarily will cease to be of value when the new Survey is completed and 12 years have elapsed.

The *New* Records will be :—

(1) The Traverse Books including Tie-Line (Kauns) Records.

(2) The Traverse Index Map.

(3) The original Detail maps, rough and fair (or tracings).

(4) The stock of printed maps.

(5) The Enquiry Register, (but none of the notes kept by Surveyors or other such field records are preserved).

(6) The Enquiry proceedings according to the sequence of numbers in the Register.

(7) The counterfoil Receipt Book for the Sanad fees.

(8) The Property Register; with a reverse Index of old S. N. or Municipal Numbers.

(9) The files of correspondence, standing orders, and significant papers relating to the general operations; pay, contingent, and other bills and accounts.

A copy of items (1) and (2) should be made and placed in the District Survey Office together with one complete set of the printed maps and duplicates of (3) or the tracings. Whenever any sheet is reprinted in consequence of corrections, the tracing of the corrected sheet from which this reprint is made should also be preserved in the D. S. O. If ever the Property Register item (8) is rewritten, then the old copy should also be preserved in the Taluka or District Record.

These records must be located in the town itself, and not removed to any other head-quarters. The surveyor who will be entertained to keep the survey

up to date cannot do his work efficiently if he has constantly to apply for essential papers to another office. General control over the survey and the maintenance of the Property Register will be exercised by the Collector and the local Revenue Officer (for some cities the Huzur Deputy is very conveniently located) to whom he may commit the direct charge. The technical work of the survey, the methods of measurement and correction of the maps, selection and care of instruments and so on will be carried on under the supervision of the District Inspector, acting under the general orders of the Superintendent of Land Records. The staff required should be appointed before hand so as to be ready to take charge as soon as the Enquiry Officer has finished his work. A surveyor trained in all aspects of C. T. S. work is essential; what other clerks, if any, are needed will depend on the circumstances of the particular town, and the help which can be expected from village officers. The Superintendent will see that the surveyor is provided with all necessary instruments and equipment from the first. After this staff takes charge, no other office or department could carry out any measurements in the city area for any purpose, except purely engineering work: nor should the Municipality maintain Surveyors for land measurement. After the completion of the Poona City Survey, Circle Inspectors were still found measuring N. A. plots in the city (R. 18-17).

147. The maintenance of a City Survey divides itself into maintenance of (*a*) the survey proper, (*b*) the registers and accounts based thereon; just as in the Revenue Survey there is a District Survey Office to deal with the survey proper and a village and taluka staff to maintain the other records and accounts. In the case of a City Survey, however, the tasks are more closely connected. All changes required to keep the Property Register up to date will not involve measurement nor correction of the maps. A maximum of 7,500 properties can be managed by one Surveyor, and he should be assisted by the village officers, and by a clerk of the standing of Circle Inspector for Record of Rights or Property Register work (Gadag R. 3492—15; Sholapur R. 9327—15). (The old staff in Bijapur, Dharwar, Hubli was graded with the Revenue staff, R. 3654—09).

148. Changes which will require to be noted in the Records will arise from—

(*a*) Government or Municipal action, such as land acquisition, street improvements, town planning and so on.

(*b*) Private transactions embodied in registered documents.

(*c*) Private transactions not registered.

Of the last a certain number will become known to the Municipality in the course of the maintenance of their taxation registers, others will remain unknown.

Transactions to which Government is a party will usually be conducted by the Revenue Officer in general charge of the City Survey. It is a matter of office routine for all such cases involving any change to be communicated immediately to the City Survey Office. With the Municipalities this is not the case, and a chief cause of the decay of city surveys in the past has been the neglect of the Municipalities to supply information and of Revenue Officers to demand it from them. It should be one of the first cares, therefore, in a new survey office to arrange with the Municipality for the *regular* and periodical submission of reports of (1) all new leases given or (2) acquisitions made, (3) removal of buildings, (4) grants of permission to build, (5) other changes which require to be recorded in the Property Register which come to their notice in the ordinary course of business, such as the death of property holders and transfers of property. Each such report should be on a separate piece of paper to suit the Self-Indexing File system. Collectors must insist on Municipalities framing a rule accordingly and submitting these returns regularly and punctually, and simple forms condensing the facts and supported by carbon paper duplicates can readily be designed.

In regard to (*b*) it will be the duty of the surveyor or clerk to go once a month to the Sub-Registrar's office and collect the information required.

149. There remain the cases which do not thus come to light. Now that chapter X-A of the Land Revenue Code is extended to all city survey areas, property holders are under an obligation to present their documents and to notify transfers of property. It is believed, however, that all owners will be ready to produce documents, when asked, for the purpose of recording them in the Register. There should, therefore, be no difficulty in recording the necessary details of documents for changes reported by the Municipality. In order to ascertain other changes there is no alternative but a *regular and systematic inspection* of all survey numbers. Even when notification is compulsory, this is indispensable. For this purpose the surveyor or clerk must visit a small number of survey numbers every day. One man can very easily visit 10 properties in a morning, without unduly interfering with other routine work, and can thus review 200 properties in a month or 2,400 a year. The Register of an average town (7,500 properties) would thus come completely under review once in three years. If there are more properties than 7,500, an extra man may be needed; but it should first be made certain that the scale of 10 properties a day cannot be increased. This inspection should be regarded as the chief ordinary routine and will be conducted simultaneously with the inspection of traverse stations, and test of suspected encroachments.

150. The inspecting surveyor or clerk will take the Register with him on his rounds and the detail map, and satisfy himself by enquiry on the spot that the entry of rights in respect of each survey number is correct; and if a change is required, enter it then and there, if the detailed information is forthcoming, or obtain it. If Chapter X-A of the Code is in force, he will report for action each case of failure to declare changes of right, using a Register as on p. 60 of Revenue Accounts Manual (1915). He will compare the map with the ground and make a note for the surveyor (if he is not the surveyor) of any change obviously requiring measurement, or map correction. If it is necessary to enter a building for this purpose and objections are offered, he will give the 7 days' notice required by the Act, and make a second visit on the expiry of the notice. Standard Forms of receipt for documents, or for intimations, and for Notice to produce will be the same as for agricultural lands.

151. The instructions attached to the Property Register form show that no Mutation Register is to be kept. Changes will be written neatly against the superseded entry after striking out the latter with a single line, so that it remains legible. Every change must be initialled and dated (in column 14) by the clerk making it. In order that inspecting officers may know exactly what changes are being made, a subsidiary Register or List will be maintained with 3 columns only: (1) Serial No., (2) Survey Number, (3) Date of Mutation. When they have been checked or tested this list can be destroyed. As support for the mutation, the report from the Collector or Municipality, or from private persons, will be filed under the survey number, or numbers concerned in the self-indexing files (of which description will shortly be made). Cases discovered by the clerk on his rounds will not, of course, have such an authority, but will be reduced by him to writing and recorded under his signature in the file, and be tested as usual. Every such entry will be attested, as are mutations in the village record, by an officer not lower in rank than a Mamlatdar's Aval Karkun, that is to say, generally, either the District Inspector, the Mamlatdar, or in the case of a taluka town, perhaps the Treasury Aval Karkun. Mutations will be posted in the Register immediately on receipt of information and need not await the completion of the revision measurements in cases in which measurement is required. When it is found that the Municipality has failed to notify a change which they did know the delinquency will be scheduled and reported for departmental action. Only in this way will they be kept up to the required vigilance.

Notice of Mutations.

152. Whether the Record of Rights, Chapter X-A, L. R. C., be applied or not, it is proper to give public notice of mutations to those persons whose rights are reduced and their friends, *e.g.*, if A sells to B, A's rights are reduced; if A and B effect a partition of property formerly in B's sole possession, B's rights

are reduced. If A dies and is succeeded by his heirs, A (though deceased) is regarded as having his rights reduced; any person who claims to be his heir, assignee, &c., can then assert himself.

Full copies (as the present law in Chapter X-A literally requires) will not be issued; but can be obtained or the revised entry can be inspected in the C. T. S. Office. The following Form of notice explains itself, and an intimation can be served by Post card in the same form at a cost of one pice each notice.

CITY. SURVEY OFFICE.

Notice of Mutations.

It is hereby notified that the rights of the following persons have been reduced by Mutations in the Property Register of the City Surveyed area in respect of the lands noted in each case.

If any person has any objection or desires further information he should apply in person at the C. T. S. Office.

Date of entry of the Mutation.	Name of person whose rights are reduced.	Nature of alteration in rights.	S. N. affected.

153. Almost all correspondence (including oral complaints or objections which should be reduced to writing and filed here if they contain anything which affects the Record) in the City Survey Office will refer to particular survey numbers: and therefore offers peculiar facilities for the use of the "self-indexing" Record system. This means that the serial number of the survey number becomes the index number of the correspondence. Every correspondence relating to survey numbers is placed loose on a shelf in the serial order of its survey number; a label pasted on the shelf itself showing us where to look for a particular survey number. Thus, above label '1—100', all correspondences relating to survey numbers 1 to 100 will be placed in their serial order. Should one correspondence deal with several survey numbers, say, 21, 168 and 375, the correspondence will be placed against the lowest serial number (21) and in the cross-reference sheet of each of the other numbers 168 and 375 a reference to survey number 21 with the date of the correspondence. If there occur in the future other correspondences containing references to these particular numbers which are filed elsewhere, additional notes can be made on the same reference sheet. The periodical reports which will be received from the Municipality will be similarly filed. If they or any other authority sends a schedule of numerous properties it will be best to file all such returns together, numbering each page of the file as it is added. In the Property Register the page of the file can be quoted as authority (without the intervention of the cross-reference sheet). Papers which are self-indexed do not require to be noted in any Barnishi. Papers which require further action (such as investigation after a period, or a reply to be sent) should be distinguished in the self-indexed files by coloured flags. When any original papers are sent away, in order that prompt recovery may be ensured a special flag must be attached. Letters which issue from the survey office relating to a survey number (or numbers) should have no other index or reference number than the survey number itself (or the *lowest* in the case of several survey numbers). The Surveyor will keep a separate record for his measurement cases (*see* para. 154

below). Under this system of filing it is not possible to discriminate between classes of papers (except such as can obviously be destroyed atonce). But since no document of title or other papers relating to city survey entries can be legally required much more than 30 years after they have been entered in the Register and given effect to, the record may be sorted out at short intervals, and all papers more than 30 years old thrown out. If the files have not become unduly bulky an even longer period may be fixed. There will be a certain number of correspondences which cannot be so treated. Such of these as require to be recorded in the office, such as inspection memos. and circular orders, will be filed together with a separate Index. Papers of no permanent interest will be placed together unindexed for destruction at the end of the year following the A, B, C, D Lists of the Revenue Department. A simple Barnishi Register in the form kept by Circle Inspectors, merely to record the fact of receipt and despatch, will be kept.

154. We come now to corrections in the survey work proper. Work for the Surveyor will be caused by alterations or re-constructions of buildings, encroachments, leases for building purposes by Government or Municipality, acquisitions, and sub-divisions of survey numbers, whether reported or found out during the review. All reports which come to the Surveyor and *prima facie* call for measurement will be entered by him immediately on a simple list, to guide him in their disposal, the reports themselves being kept in the pending bundle in the same sequence. The Surveyor will ordinarily do the review of Survey and of Rights simultaneously; if he has a clerk he may employ him for office correspondence, or may take his assistance in the Rights review.

In most small mofussil towns there are large areas of cheaply built houses in which changes must constantly be occurring. The more promptly changes are dealt with, the easier will be the task of correcting the map, by reference to adjoining land marks which remain unchanged. The more extensive the alteration, the more difficult it is to lay it down on the map. We have already provided for constant inspection of properties for purposes of Record of Rights and Titles; but cases are bound to occur continually in which reference to the fixed frame work of the survey will be necessary. The inspection of the stones which are the stations of the traverses must, therefore, be part of the routine of the Surveyor (*see* para. 32). Such stations will not be very numerous and can be readily found with the help of the "Kauns" measurements (or by scale measurements from the printed map). Missing stones must be replaced at once. In some of the older surveys stones have been buried at every Theodolite station, and this will be done in all new city surveys. Those buried too deep (as at Nadiad) need raising, and those made of soft bad stone need replacing. Broken stones should be replaced, and great care is needed to secure that they are replaced in the exact position; before removing the old stone, or after finding its position with the Theodolite, paint white lines on the ground to fix its exact spot. A restoration error of 2 inches is not to be tolerated.

155. Not every measurement case will require a reference to the original base line For instance, cases of simple subdivision. But whenever the exterior boundary of a number is changed, or the exterior boundary of the building, then the new points must be fixed from the base line from which the original boundary was fixed, or if for any reason it has become impossible to relay this, then from a new base starting from the original frame work. It is not proper to determine an encroachment without laying down again the base line by which the points in question were fixed.

156. The Surveyor must take the original detail map as the basis of his review; he must handle it most carefully and fasten it on a board and keep it covered with a cloth By careless use, rolling up the maps and using them in the hand in the street, the maps of Surat and other cities in Gujarat had been rendered almost useless within 5 years of the conclusion of the Survey (R. 3377—73). These original maps will scarcely ever be taken out except for this review and will be consulted only when there is some doubt. The Surveyor must have all the usual equipment of City Survey work. Each day he will lay the leg from one Theodolite station to the next by means of the long cord;

then he will lay the branch base lines and review at least 10 properties. Where he can see that no change has occurred nothing need be done; but if he suspects a change then offsets should be measured. When change is found to have occurred, then the action required by the circumstances should be taken. The Surveyor will mark with a blue cross or otherwise on a set of printed maps all the Theodolite Stations and properties reviewed, and he will plot all alterations writing the offset lengths at principal points with waterproof red ink upon a special correction set of the printed maps, but not upon the original map which is only used for reference (since it contains rather more detail than the printed map). Encroachments, fresh subdivisions, buildings made without Municipal permission, buildings broken down or removed, changes allowed by the Municipality but not reported by them, will each require appropriate action (sometimes the removal of a building legally terminates the lease upon which the site was granted by Government) and also correction of the records. If an error in the original map is found and established, it may be corrected in the printed correction-map, with an account of the reason of the correction filed in the S. I. Files, under signature of the D. I. L. R. If it modifies an issued Sanad, the officer exercising Collector's powers should be informed, and orders obtained. After the first round or review, the corrected printed map will be the basis of review, the originals being kept as a second reserve.

157. When the Surveyor is required to measure any property upon an application or for some official purpose, he often cannot postpone it until it comes in the usual course of his routine review; but he can go to the locality and conduct his day's review *there*, and then return to the point where he was previously working. He may mark such Numbers and Theodolite Stations reviewed *out of turn* with blue crosses upon the same set of maps and may include the Numbers in his monthly diary of review. Thus he can never say that his review work has been checked or retarded through being called upon to go hither and thither to make special measurements upon applications, &c. But no such work should be measured for map correction till the building is complete: premature measurement means either error or subsequent corrections.

158. When within the general limits of the City Survey agricultural lands are converted to non-agricultural uses, the converted land comes under the operation of the City Survey, and will be formed into a City Survey Number or Numbers according to rule. The owner will be entitled to a Sanad, and is liable to the Survey fee, which will be assessed on the new Number by the Collector. The same conditions apply to the grant of such waste Government building sites as require remeasurement breaking up into plots. A fee will also be recovered (if Chapter X-A is applied) under Section 135-G, for subdividing Survey Numbers (including blocks for which Sanads were issued to the Municipality) after private transfer, but fees cannot be charged for mere alterations in internal detail such as increase in the area built over. For all cases alike a fixed fee is desirable. This might be Rupee 1 per Survey Number, to be raised at the discretion of the Collector up to Rs. 2 or more for extra large or complicated plots involving much works. New Sanads (cancelling the old ones) will be issued to the holder of each new Survey Number after payment of the fee. When an entirely new City Survey Number is formed, as out of an agricultural Survey Number, it will be given the number provisionally allotted to it (*see* para. 85 and Fig. XXII), or such number or sub-number as will not break the sequence of the City or Ward. When a City Survey Number is subdivided into two or more, the original number will disappear, and each of the subdivisions be given letters. Thus S. N. 20 will be divided into 20 A, 20 B, and so on, or if subdivisions are very numerous 20/1, 20/2, 20/3.

Note.—Any change in an agricultural Survey Number carried out by the City Surveyor must be communicated to the District Survey Office by means of a copy of the correction, showing the authority under which it is made. The orders of the Collector permitting the conversion to non-agricultural uses of agricultural land within the City Survey area, should therefore be communicated in the first place to the City Survey Office. The land will then be transferred from the village Revenue accounts to the C. T. S. Property Register.

159. Changes in the Revenue Survey are carried out on the authority of a Kamjasti Patrak signed by the Superintendent of Land Records; one copy of which goes to the District Survey Office and one to the Village. The authority for the change itself comes probably from the Collector; the rules require the approval of the Superintendent before the correction is communicated to the Taluka and Village officers. The principle is the same in a City Survey; changes—leases of lands, removal of buildings, permissions to build and so on—are sanctioned by the Collector or Municipality; when they involve corrections in the Survey, the corrections must be carried out by the Surveyor under the direction of the Land Records Department. But the necessity for a 'Kamjasti' Patrak does not exist, since all the records are in charge of the same office. Changes which can be noted in the Register such as leases, subdivisions, &c., should be recorded straight away, without waiting for completion of the measurement proceedings. Areas can be noted afterwards. Changes in boundaries will involve entries in the following records:—

(1) The printed detail map or (in older surveys) the tippan book;
(2) The Property Register, with correction of area;

and possibly a note in the Enquiry Register and record of Sanads issued. The actual measurements taken will be plotted on the printed map used in the review. The old lines will not be scratched out in this copy, but scored through neatly with a red line.

160. Similar corrections will be made in a spare copy which will be kept apart from the general stock, and preferably in another place, to avoid risks of fire, &c. Only corrected maps must be issued to the public. When corrections are so numerous as to call for a new map of any tikka a tracing embodying all corrections but omitting the cancelled old boundaries and offset lengths and working details, will be made in the manner prescribed in Chapter VI and printed, and recorded in the District Survey Office and the corrected copy on which this tracing is based will then rank as an original map, and be preserved as such.

161. Copies of the map (or of old tippans) issued to the public must always be to scale. Unplotted (kachha) tippans are of no service to the public are liable to be misread, and must never be issued, even if asked for.

162. In the older surveys which have tippan books instead of detail sheets, a copy of the field book sketch showing the new measurements will be made and attached to the old tippan book, a note of the change being made against the original sketch. The procedure in respect of the area book will be exactly similar, extra pages showing the new calculations being attached to the original book.

163. It will not of course be feasible for every correction to receive sanction of the Superintendent, Land Records, before it is embodied, but it will be the duty of the District Inspector and Superintendent at their periodical inspections to test a sufficient number of the corrections made during the year prior to the inspection, to ensure the general accuracy of the Surveyor's work. The Surveyor will submit a monthly statement showing the number of Theodolite stations inspected and found correct, or restored; and the number of S. N. checked and corrected in his systematic review, and those specially visited.

Other Accounts.

164. A City Survey area commonly is formed out of parts of a number of villages, each of which has its separate set of accounts. It is obvious that, it would effect a great economy of time and labor, if on conclusion of the Survey, the entire city area could be converted into a single "village".

165. Now whether Chapter X-A of the L. R. C. be extended to the site or not, it is clearly better that there should be one Property Register, with the subsidiary village accounts based thereon, for the one compact area, maintained by a small central staff, instead of perhaps 6 or 8 different sets maintained by separate Village Accountants. Only the agricultural lands which have remained

in the City Survey area will remain in V. F. I, while for the N. A. lands the Property Register will replace V. F. I, II and VI. Ordinarily the limit fixed under Section 126, L. R. C., will not split a Survey Number: if it does, then only N. A. hissas within the C. T. S. limit go into the Property Register. The formation of a new "village" will naturally mean the exclusion of all lands contained in the city area from the village to which they formerly belonged. The City Survey staff are [Section 3 (1), L. R. C.] Revenue Officers empowered to collect the revenue and keep all the other village accounts required for Revenue purposes.

166. It may however prove for local reasons difficult or impossible to form a fresh village. A common difficulty will be the existence of uncommuted Watan rights.* It will be for the Collector to determine the procedure in each case before the Survey is completed. The alternative, somewhat clumsy, procedure will be that the City Survey staff will keep Village Forms I to VII (except V.) for the portions of the villages within the city area (excluding agricultural land), while the Kulkarnis will keep similar Forms for the remaining portion of the villages and for the agricultural land inside the C. T. S. limits. There will thus be two volumes of each of these Forms in each village, one kept by the Kulkarni and one by the City Survey Office. The remaining Village Forms based upon both volumes will be kept by the Kulkarni, who will also remain responsible for the collection of revenue. The need of the specified Forms being kept by the City Survey staff will be readily apparent. This staff alone is kept in touch with all the constant changes. In particular the maintenance of a separate section of V. F. IV should rest with them because miscellaneous revenue within the city area will for the most part relate to encroachments, leases and such matters which are the peculiar material of the City Survey Office. V. F. I, II and VI combine into the Property Register, and V. F. VII will be dispensed with (*see* para. 151). If the serial numbering of the City (para. 84) cannot observe the village boundaries, an Index list showing which Numbers are in each village will be needed.

167. Where this alternative is followed owing to the existence of hereditary Kulkarnis, it should be possible generally to utilize the services of the Kulkarni as an assistant to the C. T. S. Office staff. Whether it may be possible to train him to measure, and carry out simple cases of subdivision under the general responsibility of the Surveyor, will depend on the particular Kulkarni and other circumstances; but he will be encouraged to assist if he is allowed to make money by the grant of copies, the correction of Sanads, and by earning occasional measurement fees.

168. The District Inspector of Land Records and the Superintendent of Land Records will inspect and test the working of the City Survey Office according to the above instructions as often as they can. The Prant Officer and Collector will see that the village accounts and revenue work as well as the above instructions are properly attended to. Any defects found by any of these Officers will be communicated to the Director of Land Records.

169. The "Officer-in-charge" of the City Survey Office is usually the Prant Officer or the Huzur Deputy Collector. If the Mamlatdar is "in charge" it is as a ministerial officer holding charge of the records, &c. It is his duty to supervise generally the punctuality and regularity of the office-working, to scrutinize diaries, and see that work progresses regularly. Also from time to time he must test out of doors some Mutations entered by the Office.* Only an officer exercising the powers of Collector under Section 10 L. R. C. can decide all disputes and complaints, and exercise the powers of an Enquiry Officer or a Survey Officer in settlement of boundaries (Section 119), or disputes as to Government or Municipal land under Section 37 (2), L. R. C., and 50-A of the Municipal Act. Sometimes the powers of granting certain leases or holding sales are delegated to him. He will not be expected to test the technical measurement work under control of the Land Records Department.

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* It seems that a Watandar Kulkarni has the right both of keeping the accounts and of collecting the revenue.

CHAPTER XI.

Suburban Survey.

170. It has been explained in para. 16 that in City Survey we take our traverse lines down the streets for two main reasons: firstly because we can see from point to point without intervening buildings; and secondly and chiefly because that selected line is less likely than any other line to be afterwards blocked by the erection of new buildings in the middle of the streets. Of course, old, irregular and narrow streets are often, during town improvement, swept away and replaced by new, broad, straight streets, but this cannot happen universally or even very extensively in ordinary cities. When such changes are made then we must substitute for the old a new frame work to the required extent (*see* para. 173 below).

171. But when we have to deal with a suburban area not yet built over but very likely within a generation to come under building operations with or without regular town planning, we have a special problem to face. Such open areas are usually not included within a City Survey, but they have to be dealt with in the course of revenue Pot Hissa Surveys, and the more likely the building development becomes, the more desirable it is to have all the small irregular agricultural plots precisely mapped. Suppose we have to make an ordinary Revenue (L. R. C. Section 95) or Pot Hissa (Section 135 G.) Survey of an area close to a developing town. [Suburban Surveys are better done under Section 135-G than under Section 131, since the latter cannot apply to the agricultural land of which suburban areas largely consist; under Section 135-G fees can be recovered for both agricultural and non-agricultural lands. The application of the Record of Rights does not entirely make up for the loss of final enquiry under Section 131.] Being usually more open than even a village site, the cost of survey should be low, but the system of mapping should not differ from the normal City Survey method set forth in this Manual. The scale used should either be the same or an easy multiple of the scale used in the adjacent City Survey: say 160 or 80 ft. alongside 40 ft.; and 100 ft. alongside 25 ft. and not impossible proportions like 82½ ft. alongside 25 ft.

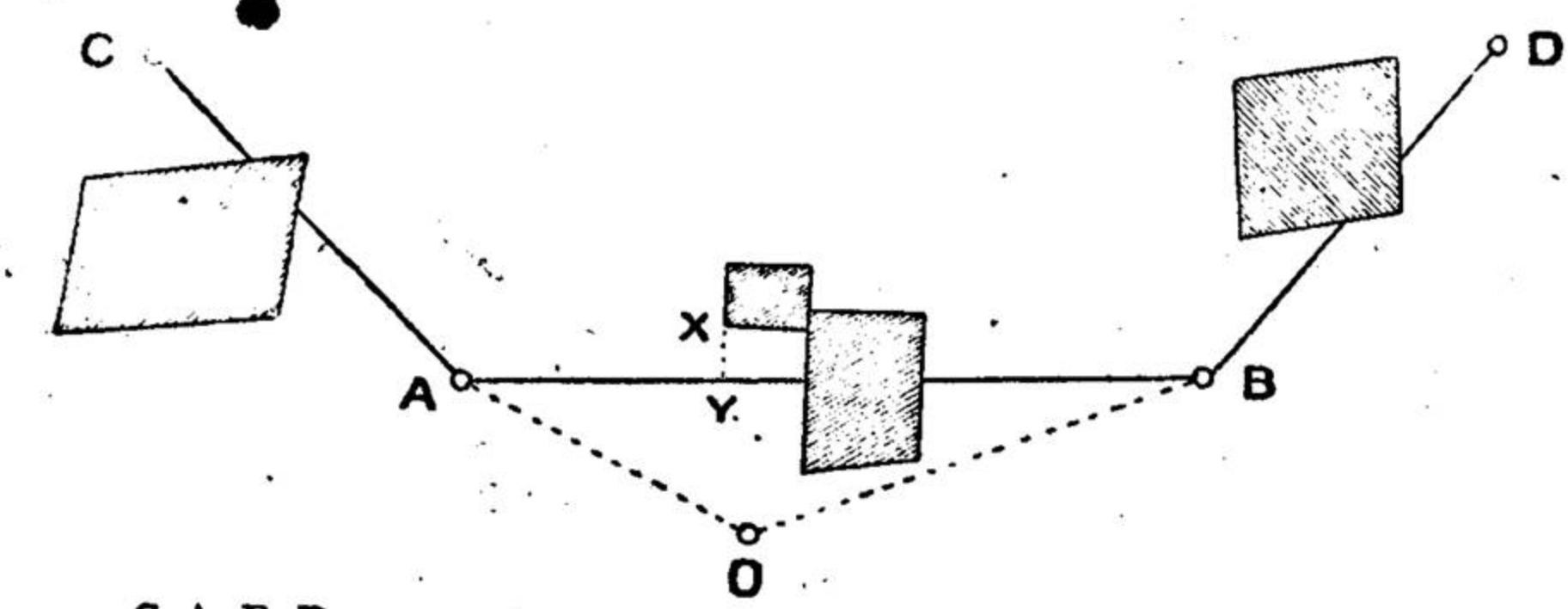
172. In the first place, it is clear that we ought to make our Survey on a large scale, so that once the frame work has been laid, we can, year by year and step by step without altering the scale, incorporate each new building scheme, whether of one or many houses, as it is carried out. If, therefore, we lay down our traverses with legs running across open fields we shall make our first map easily enough, but the frame work will very rapidly become useless for future amendments and developments; it would not be long before the lines of sight between stations became blocked by buildings. Therefore, we must choose positions for our stations as much as we can upon ground unlikely to be built over, and in choosing the line between one station and another we should, wherever possible, keep to the main road or such other lines as are least likely to be blocked. But in spite of any such care it is inevitable that in course of time parts of our frame work will become useless through being blocked by buildings. Nevertheless we can so maintain our maps that, as each such change occurs, we can correct and revise the frame work in such a way that there will be no practical interference with the accuracy and completeness of our maps. If we do this year by year in a proper way, we shall not only always have our map fully up to date and never have to repeat our survey, but also the series of maps corrected from time to time will give a complete history of all the land for a considerable number of years. New maps will be prepared from the old maps by first plotting the corrections (in *red* ink) and then tracing and printing the corrected version as described in paras. 156 and 160. Let us consider Fig. XXV, here when the land was mainly agricultural we mapped it with the traverse A B C D E, hoping that those lines would remain open, and we mapped it upon properly squared sheets, and we properly filed the traverse books showing the progressive coordinates (from zero) of A B C D. Now, after 20 years, the Town Planner lays out the area, and buildings as

shown in the Figure are erected. It will be seen that stations A, B, and D remain, while C is buried; but the line of sight from A to B and B to C, and C to D, is totally blocked. How should we deal with this situation without having to make a completely new map?

173. We must choose three new stations: b, c, d. Of these d can be easily fixed by prolonging the leg E D. We might locate c upon the old leg C D, but b must be entirely new. Having chosen these new stations, we should then take the angles along the new traverse A b c d, and we should work out the co-ordinates of b c d from the old known co-ordinates of A C D. Let us take the new station b. We must observe no new North angle but employ the old North angle of A B based on the old orientation. Then we get first the relative co-ordinates of b from A, and then its absolute co-ordinates from zero; then we plot b. Similarly then we can plot c by the old known North angle of C D applied to the short leg C c; and d from E D, measuring only the distances from C and from D respectively. Then of course we can also calculate the co-ordinates of c, d from the traverse A b c d measuring its legs as usual, and use these as a check on the accuracy of the other calculation. When we have plotted the new stations we can then draw the base lines upon the map and in the field, and all the new buildings can then be correctly placed upon the map. The new work in red ink in the figure will be traced and carried to the next printed map, and the old black work will be omitted as obsolete. The old station B, though no longer part of our frame work, may be left because its co-ordinates are known, and it may be useful in determining details in its vicinity.

174. Of course, the whole of this relaying of a revised traverse must be done *before the buildings in the new area actually spring up*. The maintenance of such a map presupposes that there must always be a Surveyor in charge, who is on the watch for alterations and who corrects the technical mapping in good time. If such a Surveyor made the excuse that the new buildings had been erected without his knowledge, it would be the worst condemnation of his efficiency. It may seem that sometimes this system of maintenance will be nearly as troublesome as making a complete new map. But we must remember that the alterations will be confined to portions of the map only: the whole of the rest of it will remain good; and the advantage of such a correction as is shown in Figure XXV is that it enables us, if necessary, to say with precision what portions of each new plot came out of the various old plots or fields. Whenever, therefore, we do a suburban Survey, even though it be not a City Survey, still it is desirable that we should adopt methods approximating to the City Survey method, in order that in the future we may be saved from the necessity of a City Survey, but may always be able to keep our maps in agreement with the changes. There is greater need of good mapping in rapidly developing area, than in areas already fully developed.

175. If, however, it should happen through accident or neglect that before the new stations can be laid down according to the method last described the lines of sight between the old stations are blocked by buildings we must then proceed thus:



C, A, B, D were stations on a traverse; all distances (C-A, A-B, B-D) are known and angles CAB, ABD. C, A, B, and D are demarcated on the ground.

Case I.—Now a house is built between A and B so that, from A, B cannot be seen. Yet it is required to test an encroachment (as by the offset YX) upon the base line AB.

How to fix the line AB ?

Set up the theodolite at A and set it at zero on the line AC. Then swinging it through the known angle CAB till it points along AB, with a surveying staff fix the line (and to save future trouble, demarcate it also by painting or cutting the mark on the house wall). Test the work by going back to zero on AC and turning the theodolite through the reverse angle (calculated from original traverse work, if not recorded) left—handed from C round to B.

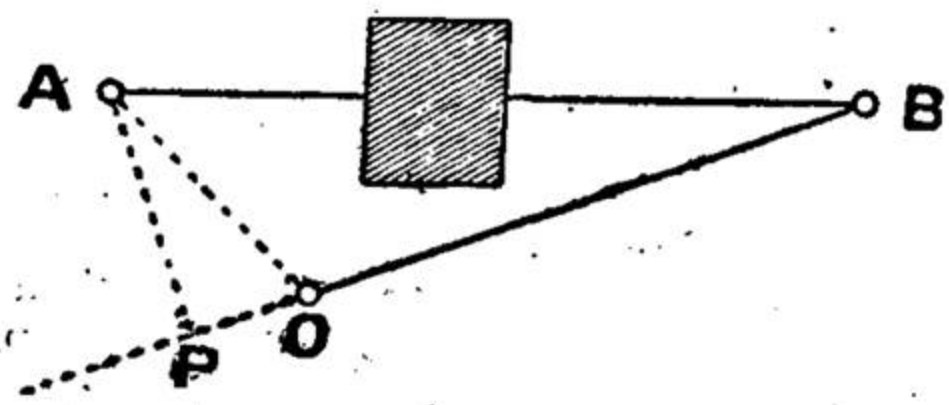
Case II.—Another house is built between A and C so that from A neither C nor B can be seen.

Solution : Set up theodolite at B and fix direction BA from the angle DBA.

Choose a new point O visible from A and B : and measure AO, and with the theodolite obtain the angles ABO and AOB : then we have OAB also known and from A can fix the direction of C and then proceed as in Case I.

Case III.—Suppose a third house also blocks the view B to D.

Solution : Choose point O as before. Observe angle AOB and measure AO as before. Then (on paper in office) make the following figure



by prolonging BO and dropping a perpendicular AP upon it. In the triangle AOP, all the angles are known and the length AO. Therefore calculate length of AP, from a logarithmic sine Table $\frac{AP}{AO}$ = sin AOP). Then in the triangle APB, AB is known (from the old traverse) and AP has just been calculated. $\frac{AP}{AB}$ is the sine of ABO which is therefore known and from it OAB : and the solution now is as in Case I. Go back to the field and demarcate the directions AB and BA and also AC and BD : and the old base line will now be just as useful as though no houses had been built. We know the co-ordinates of A and B from the zero of the map, and the azimuth of AB : therefore, we can easily get the co-ordinates of O and plot the point on all our maps and then use AO, OB, as bases for all future work.

176. If, however, the stations C, A, B, D get buried by buildings, then there is nothing we can do but to go back to the nearest stations on either sides of them in the old traverse which remain uninjured, and thence connect those stations by a fresh traverse, and then insert its co-ordinates into a revised traverse book instead of the old co-ordinates (*see* para. 173 above). Though we cannot use the old frame work any longer in such conditions for fixing a point which was determined by the old frame work, we can correctly place all existing and all future buildings in relation to the new frame work, and thus we shall be able to go on with the maintenance.

177. Even when demarcated stations have been fixed in polygonal survey by the minor triangulation method the co-ordinates of each stone are known : and base lines can be built upon such a frame work to suit any subsequent development long after it has ceased to be possible to relay the original triangles.

CHAPTER XII.

Plane Table Survey.

PART I.

[One of the finest maps on the continent of Europe, the large contoured map of Switzerland, in spite of the rugged terrain is a product of the Plane Table with a Trigonometrical Frame Work.]

1. The following instructions do not aim at giving a full account of the whole manual process, because that can more easily and rapidly be gathered from ocular demonstration. Fig. XXVIII illustrates the implements. Briefly, Plane Table Survey is performed by setting up the Table covered with a sheet of mapping paper (in the horizontal *Plane,* by means of a spirit level) at successive points called Stations, and from each of the two Stations in every pair we draw on the paper a ray to each visible mark upon the portion of the periphery which is under survey from that pair of Stations. By fixing the Table at each Station in such a way that the direction of the base line (joining the Stations) is the same at each Station of the pair (the Back-ray method) it will be perceived that we copy on the map a triangle exactly *similar* to the triangle on the ground which unites the Station points and the mark on the periphery, *see* Fig. XXIX. By scaling off on the map the equivalent of the measured distance between the Stations according to a predetermined scale, all the triangles copied on the Table are exactly *similar* to the (plane) triangles on the ground but on that smaller scale ; so that the periphery-line joining all the vertices of those triangles (the points of intersection of the rays) must be exactly the same as the periphery on the ground. In other methods of Survey we depend upon the separate measurement of each distance by links or feet usually disregarding fractions, but with the Plane Table the distances obtained are even more exact as no fractions of links or feet are disregarded: also, since all the measurements depend upon the single simple measurement of unit base lines chosen along the best available ground, their accuracy is considerably greater than in any other method of Survey except Trigonometrical or Theodolite Survey.

2. Let us carefully distinguish between the ' plane ' and ' actual ' area of any piece of land. Imagine a room 10 feet square with a flat even floor. If you order a carpet 10 feet × 10 feet, you need have no anxiety; it will fit the floor exactly from wall to wall. Its plane area and the actual area coincide. But suppose someone makes a heap of earth or a big lump in the floor 3 feet high in the middle of the room ; or suppose the floor is 4 feet higher on one side of the room than it is on the other, sloping uniformly downwards. If you then order a carpet 10 feet × 10 feet, you will find it will not fit the room, but will leave a considerable space uncovered. If there is an irregular or rounded lump in the floor then no flat carpet can possibly cover it without folds and wrinkles. The carpet 10 feet × 10 feet is the ' plane ' area of the room as it would be drawn upon a ground plan ; the sloping or the lumpy surface gives a larger area which is the ' actual ' surface of the floor. If you paid a goldsmith for goldplating the floor he would certainly charge you by the actual area, and not by the plane area ; but when we make maps or levy assessment we want the plane and not the actual. Now if we measure irregular surfaces, sometimes undulating up and down, sometimes steeply, sometimes imperceptibly sloping, with the Cross-Staff, we cannot get the plane area but only the actual area. With the Plane Table on the other hand what we get is the plane area and, therefore, if both surveys were very carefully done we ought to find the Plane Table area a small amount less than the Cross-Staff area. In a village of very uneven surface, measured by Cross-Staff separately, field by field, it is impossible that the individual fields when all plotted into the village map should fit together correctly or should make a correct plane map of the village. It is obvious that if we are making a map of India it must be a plane map, and every district and village in it must be plane, otherwise it cannot fit in. This fact that the Cross-Staff Survey obtained actual areas for the most part and then forced them together into a plane map, village by village, separately, accounts

for the very common experience that the boundaries of two adjoining villages in our old maps will not fit.

3. Of all possible sources of error in P. T. the worst is when the Table is allowed to be used in a rickety condition, so that when fixed in the proper direction of the base it does not *remain* so oriented during the sighting of the angles. This of course produces the same sort of error as would be caused in Cross-Staff Survey by using a Cross-Staff which did not keep steady at right-angles to the base. But this defect can easily be avoided by not using such a table.

4. In setting up the Table, remember the following maxims:—

(1) Fix the point on the Table at which the needle marking the Station is set exactly over the Station on the ground. This can be done most expeditiously by the eye; a plumb-line is an ultra-refinement.

(2) Level the Table in two directions at right-angles.

(3) After levelling tighten the legs of the stand. Minute accuracy of levelling wastes time; as an error of 1° in level is quite negligible. The bubble should be within $\frac{1}{4}$ inch of the mark.

(4) Align the Table *exactly* on the base, *i.e.*, upon the last backward Station: at the first Station only it is aligned on the next forward Station.

(5) Clamp the Table firmly.

(6) First and last thing, always sight the base to see that there has not been the least movement of the Table. If it has moved then correct and clamp it again and revise the rays which are displaced.

5. The pin to mark the Station must be inserted with great care at the exact point required, and exactly on the base line; an error of ·01 inch is important. All rays must be drawn truly from the pin point marking the Station. This is secured automatically if the pivoted Alidade is used (*see* Fig. XXVIII), but with the parallel-ruler patterns the edge must always touch the pin. The pencil used in drawing rays must be hard and fine and always held exactly against the edge of the Alidade, and always at the same angle.

By solid mapping is meant continuous mapping, covering the whole ground of a village or even a Taluka, sheet after sheet without interruption. The scale and orientation of all parts of such work must be the same.

By individual mapping is meant the preparation of isolated maps of single fields or blocks of fields. In such work, each sheet has its separate north point and may be made at any scale we like; though uniform scale is a valuable aid to future consolidation.

In individual mapping, no Theodolite work is done; only a selected area or plot is mapped on one sheet. In placing our first Station on the mapping paper (where positions have not been previously fixed by triangulation and plotted) obviously we must consider the general shape of the area we are mapping. If we are starting at the south end of the field, we shall place the first Station at the lower south edge of the map. If we start about the centre, then in the centre. If the area is longer north to south, then we shall take for that direction the longer dimension of the paper. The north direction must be marked preferably with the aid of a magnetic compass. In solid mapping on squared paper the north point is already determined, and points are fixed in their proper bearing by the triangulation work, and no magnetic compass is needed.

6. In choosing Stations remember these maxims:—

(1) The first condition is that the base if to be measured must be on good level open ground with all (or almost all) the marks visible from both its ends.

(2) The intersection of a pair of rays is least liable to error when the angle at which they meet is nearest to 90°; the angle should not, if it can be avoided, be less than 30° or more than 150°. The more acute or obtuse the angle, the greater the error, caused by any small inaccuracy of the ray (*see* para. 15).

(3) Therefore, with reference to a given periphery of points to be surveyed at one pair of Stations, the base should occupy as nearly as may be the position and length of the diameter of that circle which would pass through all the points. No single circle will of course pass through them all but the experienced surveyor will group his points and locate his bases according to this general conception.

(4) The base should consequently be proportional to the general extent of the field or the portion to be surveyed from that base.

(5) The base should be measured off in round whole numbers of units according to the scale, *e.g.*, at 25′ to 1″ bases of 75 or 125 are better than 68, 94 feet 3 inches, and so on as the risk of error of calculation is far less; and test is easy.

(6) The fewer the number of Stations, the better.

In Fig. XXX a group of points M, O, L, P, &c. constituting the periphery of land under Survey is depicted, and three possible bases (one of which contains 3 Stations) are drawn, while 3 or 4 other bases which would be unsatisfactory are also indicated. AB or A′B′ are best, while XY has too many points (like O) too close to it giving bad angles of intersection. The angle of intersection at M is a good one; that at P is bad. There is no objection to one or more points (like L) being on the base itself, since they can be determined by direct measurement in the course of measuring the base; subject to condition (1) above, one of the periphery points may be taken as a Station.

The base line and the Station should be selected on the most convenient ground. Pebbles and sand and soft ground are bad for Stations. It is not necessary for the base to go through the middle of the land under Survey; it can lie outside it, if the ground is better and marks can be well seen and intersected. Where it is possible to maintain all the Stations in one straight line, this has advantages; for (*see* Fig. XXXII) if the third Station is placed an inch or two out of the straight line (3′ instead of 3), then the fourth Station instead of going farther away, will be likely to come back into the straight line again.

7. It is always most desirable to decide on the position for two or three Stations ahead of that at which we are working. The chief necessity is visibility of the marks to be sighted.

Fig. XXXIII shows a series of bases such as might be adopted for surveying a large block of land. It combines the advantages of rectifying the alignment by a series of Stations in one straight line, and also of diagnosing the accuracy of the work by moving to a Station not in line with the last base. The dotted lines show the straight sights obtainable for assuring the orientation. Obeying the rule which recommends our bases to be in whole units of lengh, it would not happen that Station 4 fell quite exactly in the same line with base 1—2. But if we choose for our 4th Station a point approximately on the line 1–2 produced, we then have the advantage of scrutinising the work done upon base 2—3 and diagnosing any error found; and not only of aligning our Table primarily by the back ray upon the base 4—3, but then of confirming that alignment by observing Stations 2 and 1 which should be very nearly in line. If for instance Station 4 as plotted on the map is to the south side of 1—2, we shall not expect to find that line on the left of our line of sight from 4—2.

8. (1) *The marks* indicating the periphery points and Stations must be vertically upright and, therefore, not higher above ground than necessary for visibility. When necessary to make them visible above bushes, &c., two poles may be tied together; but it is very hard to keep such long poles exactly upright. It is best, therefore, to put a coloured flag at the upper end, and to that end attach a long string with a stone or lead weight hanging down as a plummet. Then the pole should be so held that the plummet, and not the base of the pole, hangs over the mark to be observed. This secures that the flag (which is in this case to be sighted) shall be vertically over the mark (*see* Fig X). For open positions small pointed iron rods (Fig. XXVIII) are the best and cheapest in the long run. In sighting any mark, the thread of the sighting rule must rest exactly on the lowest visible part of the mark. The thread must be fine, and not thick, doubled or woolly.

(2) Adjacent marks must be different in colour (or kind) to avoid confusion ; Surveyors should be provided with cloth-flags of 4 or 5 colours. As the rays at the first Station of a pair are drawn on the mapping sheet, the nature of the mark (blue, red, tree, stone, blue, post, &c.) must be written against each to avoid confusion when intersecting by the ray to the same mark from the next Station.

(3) Sometimes a stone in the ground or a tree on the exact boundary required can be used as a mark. When a tree is sighted, care must be taken to sight the exact centre of its round trunk, because if the edge of the trunk is sighted the intersecting rays may really meet several feet beyond the tree (*see* Fig. XXXI). Similarly when other objects are chosen as marks, a sharply defined point must be selected. In City Survey, flags are less needed, as distances are small and corners of houses, steps, gate-posts or chalk marks on walls do quite well for marks, and are not likely to be confused when the nature of the mark is noted against each ray as it is drawn.

(4) The scale for ordinary purposes in Sub-division Survey will be 1¼ chains (41¼ ft.) per inch where the Hissas are small and 2½ chains (82½ ft.) to the inch in dry crop lands where Hissas and Survey numbers are large. Only in the *very largest* numbers will the scale of 5 chains (165 ft.) to the inch be permitted where the Survey number exceeds 60 chains in length and Hissas are not small. In village site or City Survey 40, 25 or even 20 feet is a better scale than chains since it is more easily divisible (*see* para. 28 *infra*).

(5) Before commencing mapping, go round the field or block of land, make a hand-sketch of its periphery and dimensions and show on the sketch the colour or kind of mark placed at each of the bends or corners. This will save time and prevent confusion between the marks. Such a sketch is not necessary in small court-yards or restricted spaces in City Survey.

9. The following special devices can be adopted in difficult circumstances :—

(1) Select a point for a new Station not in the same straight line with the last two Stations and not accessible by direct measurement. In Fig. XXXIV if A and B are the last two Stations, then a third Station C marked by a flag can be sighted and its position ascertained *without any measurement at all.* This would be helpful if cactus, a nala, or wall intervened.

(2) Sometimes the position of single marks can be conveniently got by direct measurement from a Station along a ray, specially when it is close to the Station, without intersection from a second Station (*see* F in Fig. XXXVI).

(3) Invisible marks can be mapped by setting up subsidiary guide marks in positions that can easily be seen. One way of using such a subsidiary mark is to place an auxiliary mark in a visible position, and then plot the true mark from it as in Fig. XXXV.

Let A, B be the two stations most convenient for mapping the boundary C, D, E, F, G. But F is invisible because of a house. Take a point F′ in the straight line EF and a measured distance from F. Then fix F′ by intersections as usual, and then finally plot the position of F by scale upon DF′ produced.

(4) Sometimes the position of a mark which can be seen from one station only can be got by the intersection of the ray with a line joining two other fixed points, especially when the invisible mark is on the straight boundary between two fixed corners of a field. In Fig. XXXVI.

A B corners of a S. No.

C D Stations on base.

C E ray to mark E which cannot be seen from D ; but knowing that the line from A to B through E is perfectly straight, join A B and where it cuts C E is the position of E. This is a valuable dodge in Hissa Survey.

F is a point invisible from C ; draw the ray DF and measure distance on the ground and scale off DF on the map.

(5) When we are observing marks which are situated high up a steep hill side or far down a steep slope, we shall not be able with the sighting rule on the levelled Table to see those marks through the eye-piece and wire of any ordinary sighting rule. But we can draw the ray correctly in this way :—*see* Fig. XXXVII: stand back 20 yards behind the Table and get the peg which marks the Station O and the distant mark up or down the hill side exactly in line with the eye. Then cause a peon or assistant to plant a small mark 10 or 20 or more yards (the more the better) in front of the Table, between the station and the distant mark, on the true line of sight so that it exactly covers the distant mark. This can be placed in *such a position* that on returning to the Table we shall now be able to see the auxiliary mark through the sighting rule; and since it gives the exactly true line to the distant mark we can draw our ray correctly.

(6) Any two Stations in such a series as shown in Fig. XXXIII form a base and not necessarily only the two adjacent stations : *e.g.*, if a point X behind a small hill can be seen only from 3 and from 7 it can be sighted from those Stations as indicated just as though the line 3-7 were a single base.

10. When after measuring one block of land the adjacent block has to be measured separately on the same or another day, the boundary that has once been measured will do for *both maps*, if the same marks are kept standing at the two *ends* of the boundary, and the same scale is used. The intermediate bends, &c., can be traced off.

Do not require too many labourers; get the flags driven into the ground and left standing there by themselves; the more men you want, the more difficult it is for property holders to provide them.

For marks at a short distance, quite small rods even 1 or 2 feet in length are big enough. Long and heavy marks should be used only for distant points hidden by crops and bushes.

Remember that uneven ground, even the steepest hill side does not affect the accuracy of the work if the base measurements are taken along flat ground. If that is anywhere impossible, stations not on the same level may be used, and the horizontal distance between them can be trigonometrically determined either by observation from two lateral Stations (*see* para. 30, C. T. S. Manual or by calculation from observation of the vertical angle (*idem*).

11. After putting marks in position in field survey, it is sometimes difficult owing to distance, undulating ground, bushes and crops, to distinguish them. Expert Surveyors have trained one or two men or boys to run round the periphery and place a hand on each mark in turn; then if the Surveyor can properly see it, he blows once upon a whistle; if it is not distinct he blows twice and the boy stands exactly over it and holds aloft a more conspicuous flag till the mark is truly sighted. Then on hearing one blast he goes on to the next till all are finished. Upon three blasts being sounded, he pulls up the marks and brings them in, as finished with. Thus much time can be saved.

Part II.

The following further notes are made for the use of those who have studied geometry and have to direct operations.

12. Let A, B, C, X, Y, be points upon the ground, while a, b, c, x, y, are the corresponding points correctly marked upon the Plane Table map: then ax is the ray drawn upon the map by placing the fiducial edge of any ruler or alidade across the points ax while AX is the line of sight in the field from point A to X. When from Station A ax is correctly aligned upon X, then when the sighting rule is laid along ax the line of sight will fall upon X and every other ray will coincide with the corresponding field marks.

13. It is sometimes supposed that if A, B and C (Fig. XXXVIII) are three successive Stations, and the point X has been observed from A and from B, getting an intersection at x, then if it is again observed from the Station C and found that the ray cx does not pass exactly over X, then the position of x ought to be plotted somewhere in between the two positions, such as y. This is not correct, because if the ray cx does not fall upon X, the reason is *not necessarily* that the sightings from A and B were wrong, but equally likely that Station C is slightly incorrectly placed. It may not be quite in the true line intended, or it may have been scaled 1/100th of an inch too short (it is too short in the diagram) or too long. In any case, when cx coincides with CX we are *sure* that c is right, and x is right; but when it does not coincide, it is just as likely that c is wrongly placed as that x is wrong. Our Plane Table measurements and instruments cannot attain greater accuracy than is represented by an error on the map of ± 1/100th inch. The pencil lines and points we draw are not so fine and devoid of dimensions as Euclid supposes, and therefore, a small difference of the ray cx from the plotted position of X is not significant, but if the difference is found to be considerable, say, 3 or more hundredths of an inch, then instead of taking an intermediate position for x we should again examine the plotting of Station C and the alignment of the Table and endeavour to reduce the difference, and not proceed to a fourth Station till it has been reduced. Having made sure that C is correct, both in scale and alignment then the possible errors are either in the *scaling* or field measurement work, or in the *rotation* (displacement) of the Table.

Error of Scale.

14. Let A, B, C (Fig. XXXIX) be three successive Stations and X, Y, Z be points upon the periphery under Survey. On the map, a, b, x, y, z have been surveyed and fixed at a certain scale. Now if we meant the scale to be 100 feet to the inch, but by some error of measurement or inadvertence we have plotted ab too $\frac{\text{short}}{\text{long}}$ the angles in our map will still be quite correct; but the whole scale of the part of the map based on ab will be $\frac{\text{less}}{\text{greater}}$ than we intended and the points x, y, z will be $\frac{\text{nearer to}}{\text{farther from}}$ the base ab than we intended. From B we proceed to the Station C and if we measure and plot the next base BC correctly (if we are testing we must be absolutely sure of this) then when we have aligned the Table upon CB we shall find that the ray cx does not fall upon X but a little $\frac{\text{inside}}{\text{outside}}$ it (*i.e.* $\frac{\text{nearer to}}{\text{farther from}}$ cb) and the same phenomenon will be observed *on both sides of cb.* When, therefore, at the third or subsequent Station we observe this discrepancy of a symmetrical displacement on both sides of the new base, an error of scale is indicated and we should recheck the plotting of the base.

Error of Rotation.

15. Upon the base AB (Fig. XL) we are surveying a periphery in which X, Y and Z are points. After setting up the Table and drawing rays correctly at A we move to B and either in our original alignment or during the progress of the work at Station B the Table is displaced or rotated through an angle so that the ray ba falls to the *left* of BA. Then the directions of the rays bx, by, bz will be thrown to the left of the correct position (as shewn in the figure) as though instead of the Table having turned to the *left*, the points upon the periphery, observed after the rotation, had moved in a circle round B in the opposite direction, right-handed.

Now it will be seen that both x and y are displaced in the same angular direction and to a distance which depends upon their distance from b and the angle at which the rays intersect. The actual displacement represented by yy′ is determined by the formula.

$yy' = \frac{by'.\ \sin\ l}{\sin\ q}$ when l is the rotation angle (A′BA) and q the angle at which the correct rays intersect (ByA) the angle of rotation will be ordinarily small and constant; this displacement is, therefore, least (for a fixed distance from b)

when the angle of intersection q is 90° but it becomes infinitely great when the angle of intersection is either 0° or 180°. This is the foundation of the rule in para. 6 (3). The distance upon the map from b is in exact proportion to the distance of the field point from B. Hence the displacements (oy′) at right angles to the rays from b are all proportionate to the distance of the field marks from the station B. This is a theorem we shall use in para. 25 below. When the angle of intersection q is everywhere between say 60° and 90°; the displacements will all be in the same direction and almost in the same proportion; so that the distortion of the map will not be conspicuous. So long as we are mapping upon two Stations only, a small rotation will make a still smaller difference to the accuracy of the map. Nevertheless, great care should be taken to observe Rule (6) para. 4 and carefully to guard against errors of rotation by always observing that the direction of the base is perfectly correct, as the first and the *last* operation at each Station throughout. Any table which is unsteady and alters its orientation under the mere pressure of the hand while drawing or by slight contact with the coat or arms of the Measurer must be rejected for repairs.

But if after mapping upon the base AB we proceed to a new Station C, then if there has been any rotation at A or B these errors are serious, since the next part of the map will not be similarly rotated. If we find there has been any such error, we must endeavour to get rid of it. If several errors have been made no diagnosis is possible. We shall find only a confusion of differences over all the work. But if only one or two mistakes have occurred diagnosis and correction is possible.

16. Let us further consider Fig. XL. Here we see first the Station A from which a series of rays was correctly drawn with reference to the base AB. This series of rays all meeting at A, drawn to all the visible points on the periphery, form what is known in Geometry as a 'pencil' at *a*. Upon being set up at B the Table should have been so aligned that *ba* coincided with BA, but during work it was rotated accidentally, so that *ba* fell in the line BA′. Such a rotation cannot be through a large angle, since it would require a recklessly careless operator who failed to notice a large movement, or who failed to detect it if he were observing points almost in the direction BA. But sometimes through the careless moving of the flag or mark which indicated the Station or through confusion of marks, the operator might align his Table upon a mark somewhere in the direction A, but not actually the Station A, and so overlook a serious rotation error. The effect of such a rotation is that *a*, and all the 'pencil' at *a*, will have rotated with the Table just as though all the field points had actually revolved in the opposite direction round b. If we now intersect the rays of the pencil *a*, all the intersection-points will move along the rays of the pencil. The point at which two rays intersect may be regarded as an iron ring through which two rods pass; it can move up or down, but only in straight lines along the rays. By the rotation described every point of intersection on the pencil *a* will move along its rays in the same direction as the base *ba* has moved (*i.e.*, opposite to the revolution of the Table). As shewn in the Figure, all the points on the right of the line BA will move nearer to A, and all on the left will move further away, every point thus moving in the direction of the arrow. The actual distance of movement depends on the formula already discussed, from which we can see that the points nearest to B, and those which are nearest to the circumference of the circle of which AB is the diameter suffer the least displacement because in the one case the distance from b is small and in the other the angle at which the rays intersect is most nearly a right angle.

17. Now suppose such a displacement has occurred and not been discovered even by sighting the base BA as the last operation before leaving B. The Surveyor then goes to Station C and correctly sets up his Table: what would he then find? (1) that the base points *a* and *b* are still quite correct; (2) that all other points seem to be displaced in a varying degree. Those on or very nearly upon the straight line CA are not perceptibly displaced. The mapped points to the left of *ca* are all displaced in a direction away from *a*; those to the right of *ba* are all displaced in the same direction, towards *a*. But if there are any

points lying within the angle CAB or its vertically opposite angle C'AB', these will have reversed their movement and will seem to have gone to the right so as to make the rays such as *cz'* fall on the right of the field marks. We can now see that the effects of a rotation when seen from a third Station are that (excluding the small sector between the three Stations) all mapped points are displaced *in the same direction.* Is it possible from C to determine about which of the two Stations, A or B, the rotation occurred? It is, *if c is not in a straight line with ab,* because then it will be seen that the points upon or almost upon the line ca will be much displaced, and those in the direction of cb will show practically no displacement if the rotation was about *a*, *i.e.*, at Station A; and *vice versa.* On the other hand if *c* is in the straight line *ab* we must judge between B and A by ascertaining whether the displacement is less near A than near B; which Station was the centre of displacement will be indicated by less error in the points near that Station.

If our bases are in a continuous straight line, then the sector in which rotation is reversed disappears, and makes it much easier to determine whether the error is one of scale or one of rotation, but not easy to decide at which station it occurred.

18. Errors may be committed also in centering, *i.e.*, in setting the Station marker upon the Table exactly over the peg in the ground (*see* Fig. XLI) in which the proportion of map to field is very large. Let A be the peg and *a* the Station marker. Then if they are not correctly set up and if we look upon them vertically from above, we shall see that in order to get *a* over A, two movements of the Table are needed. First a rotation movement at right angles to the base BA, and secondly a scale-movement in the line of the base; then the point a will move to a' on the map. Therefore every error of centering can be resolved into a slight error of scale and a slight error of rotation. Another source of possible error is in inserting the pin to mark the station. If we are surveying at a scale of 100 ft. to the inch, then one-hundredth of an inch on the paper represents one foot in the field. It is almost impossible to place a pin within one hundredth of an inch from a required point. The diameter of any ordinary pin near its point is fully two-hundredths of an inch. Therefore the diameter of a pin represents an error of 2 ft. on the ground. A rotation error represented by a misplacement of ·02 inch in a base length of 2 inches means a rotation through an angle of 35′. Hence a steady hand and good eyesight and the correct placing of the pin on the map, and exact centering over the peg on the ground are most important. It will be seen that a much larger error can be made while inserting the pin than one is likely to make in placing the Station over the peg.

19. Therefore upon setting up the Table at a third Station C we should before drawing any fresh rays first check the position of the Table upon the last Station *but one*, and upon some conspicuous marks already surveyed from the last pair of Stations. If we find these fall correctly into line with our map on the Table as set up at C, we may be confident of the accuracy of the work. But if this agreement is not found, we must analyse the discrepancies and endeavour to diagnose their cause and remove it before we proceed to draw the rays from C; but we must not "average it out" by drawing fresh rays from C and taking intermediate positions as in Fig. XXXVIII.

20. It is often required to know how a Plane Table map can be tested and also it is necessary to know how to use it to restore lost boundaries, or possibly to insert further details in the same map in an area already mapped or in some adjacent block. The method is as follows:—

To check or to restore a single field boundary which has been mapped by P. T. when we have no P. T. available; convert the P. T. map into a 'tippan' or record of Cross-Staff measurement by ruling any suitable base line from recognisable and admitted points across it, and then offsets to all corners with the offset scale (Fig. XXI). We then get the familiar form of tippan drawn to scale, and with the Cross-Staff we can fix all the corners (*see* in Fig. XLII one Survey number so converted). We can of course measure the 'bandh máp' or lengths along the boundary if we have nothing but a Chain or Rod available.

21. Fig. XXXIX represents a P. T. Map of a certain area. We desire to test the map, or to continue or supplement it. We go back to the field and on comparing the map with the ground we find three points A, B, C (such as theodolite Station stones), demarcated or still clearly evident and apparently agreeing with the map. They do not seem to have been recently changed. The other points in the map are indistinct, and boundaries perhaps are ploughed over, and we cannot be quite sure, whether they coincide with the map or not. We have to determine and demarcate their exact former positions. In the first place, we should see whether it is convenient and easy to set the Table up exactly over one of the points A, B or C which can be found. First let us suppose we can conveniently set up the Table at point B. Then set it up with the old mapped point b exactly over B, then cause a flag or mark to be placed at A and C. Turn the Table till the ray from b to c falls on the flag C in the field. Then see whether with the Table in that position, the ray ba also falls on the flag A. If it does within a reasonable margin of error (one or two hundredths of an inch on the map, one or two feet in the field) then we may presume that the position B is right, and the Table may be clamped, and we are now able to test the work. If we sight the rays from b to any other points on the map (if correctly prepared) they will fall in the field upon the points originally sighted. We may then find the stone or other mark on the ground which is sought for by scaling the distance on the map from B to the points concerned and measuring the same distance along the ground; or we can plant pairs of flags along the required ray and then move the Table to A or C and determine the intersections on the ground of the rays from A or C with the so demarcated rays from B.

22. If we have to restore a number of points, as when by flood or neglect boundaries over a large area have been obliterated, it is best to send two Surveyors with exactly duplicate maps. When these are set up at two points, each boundary mark can be rapidly fixed by two assistants (each under the direction of one only of the Surveyors) moving their flags along the rays from each Table till they coincide. This also gets over the difficulty of the difference between plane and actual area in uneven ground. The P. T. map gives the plane area, and therefore, when the ground is not flat the distances scaled from it must be applied to the ground by the reverse of the process suggested in Fig. VI. A valuable plot of land adjoining the I. P. Mission at Surat on the Tapti Bank was nearly lost through forgetting this point when using old C. T. S. Records; an appeal to the High Court succeeded in getting the evidence corrected.

23. In the next case, let us suppose that it is not possible to set up the Table at A, B, or C, or any other point marked on the map. We then have to find a point at which the Table can be set up and the map tested (or continued). Suppose there is a river as drawn in the sketch, and we wish to set up the Table in its true position at the point O beyond the river. Then take the Table to O, set it up, and level it and clamp it. Do not place the old map on the Table but a blank piece of transparent tracing paper. Place a pin or Station Marker in the tracing paper exactly over the Station O. Draw the rays oA, oB, oC to the marks identified in the old map. Then take the tracing paper off the Table. Replace the old map on the Table without pinning it. Then place the ray oA across the point a. Turn the tracing paper about until oB also falls upon the point b, and oC falls upon c. When these three rays all exactly intersect the three points, then prick through the tracing paper and mark the point O on the map. Place this map point correctly over the Station O, and pin the map down, and orient the Table so that the sighted ray oa falls on A. Then ob, oc should likewise fall on B, C. Now our map will be in its correct position, and we can continue further work from the Station O (on the same scale as before), just as though the point O had been fixed and mapped at the time when the old map was prepared. Any point in any plane Table map can be thus determined. We could then from point O replace any missing boundary mark or point in the ground covered by the old map as already described. This method of fixing a new position on a map or chart from three positions previously mapped is much used in Marine Surveying, and the instrument by which the three rays are marked (and which in these notes is replaced by a piece of

tracing paper) is known as a Station-pointer. When a ship is at sea, it cannot put marks in the ground, nor can it measure distances along the surface of the water, and yet by means of the Station-pointer it can survey a whole coast after 3 points on the land have been first determined.

24. If a circle is drawn circumscribing the triangle A, B, C and O is upon or near the circumference of that circle, then this method breaks down (*see* Euclid III, 21). Therefore if this condition seems probable, one of the three points must be changed. In the Figure, O falls outside that circle. If A, B, C are nearly in a straight line, there is no fear; but if A, E, C had been chosen, the method is impossible because the angles AOE, EOC, COA are the same for all points on the circumference of the circle AECO.

25. This leads us to the theorem of the *triangle of error*. The position obtained by the Station-pointer or three-ray method in Fig. XXXIX can hardly be defined very sharply with ordinary instruments. Euclid presumed that our lines and points had no dimensions whatever, but the ordinary pencil line and point drawn in mapping is likely to be fully 1/100th of an inch in diameter, and even with microscopic adjustment we shall probably find that the point determined upon the map will not quite exactly give rays falling over every one of the field marks. We then have to find a method by means of which we can get more exactly to the required point. Set up the Table and orient it as nearly as you can with the Station-marker at the point O, (Fig. XLII) determined with your tracing paper. Then choose any three points C, A, B, not equidistant from the Table and not lying on a circle through the Station O. The points upon the map are c, a, b.—Fig. XLIII. Now with the sighting rule draw the ray from o through c to C and clamp the Table exactly in that line. Then, placing the sighting rule upon a, we shall, probably find that oa will not fall upon A. Draw upon the map the true line aA (not oaA which is not a straight line) then likewise draw the line bB. These three lines if they do not meet in a point, must form a triangle. Now the question is what is the true position of the Station at which we stand. If it is not strictly upon the line ocC then we can get to the true position by some movement of o, which involves a rotation of the Table about some unknown centre. This rotation will however, displace *all* the points in the map (i) in the same direction; (ii) in proportion to the distance of the field marks from the Table (*see* para. 15). Therefore the true position of o must be on the same side, *i.e.*, either upon the right or upon the left of *all the three* lines aA, bB, cC. This is the first key to the problem. Its true position cannot lie anywhere which is on the right side of one ray and the left side of another. It cannot therefore fall inside the triangle, but the only possible positions are in the segments marked I and II. We have now only to determine in which of these two it lies. Now when rotation has occurred, we have already seen that the distance of the displacement of each point is proportionate to the distance of the field point from the Table. Now the points C, A, B are not equidistant from O. Therefore, we must find some position for o in one of the two segments I or II in which its distance from cC, aA, bB will be nearly proportionate to its distance in the field from C, A and B. This is the second key to the problem. Now if we try in segment I, we shall find that any such ratio is impossible. But if we try in segment II we shall find it is quite possible; and we shall find the position o′ closely fulfils the conditions. Now place the Station-marker at o′ and align o′aA, and then try the remaining points. We shall find that they coincide much more closely than before. If there still remains a small difference very carefully repeat the same process, and having obtained a much smaller "triangle of error," refix o with still greater accuracy. If we find that no position can be found which will quite exactly coincide with the map then of course there is some inaccuracy in the map or some movement in the marks in the field. We must not expect an impossible degree of accuracy, and an error represented by less than 1/100th of an inch on the map may be disregarded.

26. Another way of considering this problem is this: if the map upon the Table is set up exactly correctly, then we may imagine solid rods fastened by hinges to the distant field marks and passing through rings on the Table at the corresponding map-points. These rods will all meet exactly at O. Now if

the Table is moved forwards, backwards, or sideways, so long as its orientation remains correct, the rods sliding through the rings will continue to meet in one point (*i.e.*, the map-point which is over the ground-point when the table is at the moment). But as soon as the Table is revolved out of its true orientation O is no longer correctly centered and the rods do not meet in one point; *all* the rods would be so displaced as to have the true position of O on the same side of them; it cannot be on the right of some and on the left of others.

27. We are very frequently required to use the P. T. to interpolate details between two points already fixed trigonometrically. When a theodolite traverse or net work has been worked out and its co-ordinates determined (*see* paras. 23-28) the positions of the stones can be plotted exactly on a mapping sheet ruled in 1″ squares. This sheet may then be given to a P.T. Surveyor to fill in the details. He will go to one of the stations which he will find demarcated on the ground and will set up his table over it exactly aligning it upon another of the demarcated and plotted stations. Thus having fixed his first Station and first base, he will go from Station to Station at his own choice. To guard himself against rotational or scale errors, he should frequently see that his Table remains so oriented that from the tation at which he is working, the rays to the plotted trigonometrical Stations still coincide exactly with the visible Stations. If he works from the first Station all the way to the second, using 20 or 30 Stations in between, there is great danger that small errors will accumulate until he cannot satisfy this condition. It is therefore, wiser, after having proceeded about half way from the first trigonometrical Station towards the second, to break off and take his Table to the second trigonometrical Station, and set it up there and work back to meet the first portion of his work. If he can get the two portions to join with moderate accuracy, he will then be certain that the whole work is correct. When they do not join so accurately as could be desired but he gets one position from one chain of work and another from the other, he will then choose that position which gives him the best agreement with the fixed trigonometrical Stations, and cancel the positions which give a worse agreement; if the difference is considerable, he must revise his work. When interpolating details upon a series of such Stations, he will thus always start again correctly at each predetermined Station, and no error made in any part of the work will be continued or will influence other portions.

28. The scale of 16 inches to the mile (1 in. to 330 feet or 10 chains) may be taken to be the dividing line between large and small scales. A scale of 1″ to 20 feet is "large"; 1″ to 1,000 feet is "small". The reasons for adopting large scales for our P. T. work are these:—

Errors of rotation displace points to the same relative extent, whether the scale be large or small.

Errors in scaling are more serious when the scale is small.

Errors of centering are therefore relatively more serious when the scale is small.

Errors in the insertion of the pin and errors of drawing are very serious when the scale is small.

Hence the most accurate P. T. results are got (assuming the same degree of care and judgment in both cases) when the scale is large; very accurate maps can be got by surveying on a large scale and reducing by photography to any desired smaller scale.

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CHAPTER XIII.

Village Site Surveys.

1. These can be conducted under Chapters VIII and IX, L. R. C. subject to the provision in Section 131 that, when the population is less than 2,000, the Survey Officer can call upon the villagers to attend and to give assistance in the operations and provide flag holders, or he can assess the cost thereof but not of the Surveyors, &c.. Likewise under Section 135-G (*a*) and (*b*), the map of any village site may be made after the Record of Rights Chapter X-A has been extended thereto, and the (full) costs can be recovered. If Section 131 is applied, then an Enquiry can be made; but Sanads can be charged for under Section 132 only when the population exceeds 2,000. Of the two provisions of law under which a village site can be mapped, Section 131 enables us to recover only the cost of flag-holders; under Section 135-G, we can recover all costs except the cost of making the Enquiry. Under the former provision, we can issue Sanads; under the latter, we can frame a Record of Rights which will acquire presumptive value as evidence, and there would still be no bar to the application of Section 37 (2) if in the course of the Survey there was found to be a dispute between Government and an occupant. When the Survey is done under Section 131, agricultural lands are excluded, and since in many villages there are considerable wedges of agricultural land which impinge upon, penetrate or are enclosed in the village site, it will at the same time be advisable to map these under the provisions of Section 135-G. It is therefore more expedient to employ Section 135-G.

History.

2. In R. 9661-96 emphasis was laid upon the need of evidence to protect public rights in land in village sites, and the difficulty of obtaining such evidence. Again in R. 4054-01, the need of village site Survey was again expressed, and reaffirmed in R. 1663-02 and R. 4964-06. Finally, in R. 4727-09 experiments were ordered to be made. But further in R. 9863-09 it was decided that until the Pot Hissa work throughout the Presidency was brought to completion it would be well to postpone this heavy task of surveying village sites. The experiments first made and the rules drawn up were for a Cross Staff Survey, and it promised to be a very slow operation.

3. Meanwhile the development of the Plane Table process for the Survey of sub-divisions in agricultural land led to further experiments in its use for surveying village sites. The author of this Manual, in his capacity as Court of Wards for Surat District, first surveyed a village site which was his own property and from which the Inamdar—his Ward—derived rents. The result was so successful, as reported in R. 5407-14, that further experiments were sanctioned. First 7 village sites in Pardi and Chikhli were taken up, and 3,023 properties were measured at an average cost of 4 annas 9½ pies, not including cost of Enquiry. This experiment was favorably reported upon, but it was doubted whether equally satisfactory results could be obtained in the much more congested large villages of Central Gujarat (R. 221-16). Consequently, a further experiment was tried in Broach District (R. 2671-16); and 5,662 properties were surveyed at a cost *including* Enquiry and framing of the Property Register, of 9 annas per property in the villages with population above 2,000, and excluding Enquiry at a cost of 6 annas per property in the smaller villages under Section 135-G. The average cost of the *Survey* of all these properties in Broach was 5 annas 8 pies. This gave an increase of only 10½ pies per property over the Surat results, though the congested villages selected were at first believed to be likely to prove the method impracticable. It should be noted that in addition to the survey of 5,662 properties in Broach District, 972 encroachments were removed at the first Enquiry, and 112 more after some investigation. In the result, 1,084 plots of land aggregating 8½ acres of valuable land, probably worth as much as the gross cost of the whole survey, were

recovered for the State. The rate of progress throughout these operations was 9 properties per day, and the cost given includes the printing of the maps (R. 5249-17).

4. Thus a practicable method, not too expensive and not too slow, has been worked out and stands ready for application to all the village sites of the Presidency. However, for the same reasons as were given in R. 9863-09, it was again decided in R. 5533-16 not to proceed for the present with further surveys of the kind.

5. The City of Kingston (Jamaica) has been successfully surveyed in this manner, chiefly employing the Plane Table. The method of this survey differs but slightly from the method of City Survey described in this manual. The chief difference is that, in villages, houses are not so closely blocked together; even when we find a double row back and front it is still possible to go all round the outside and mark the divisions between houses on the external walls and get the position of the internal walls without any entry into the houses or internal measurement. At any rate, there is very much less of this than in cities. Since there is more open land and one can see across compounds and backyards with less obstruction from buildings than is possible in cities, direct Plane Table mapping can be used far more, and the Theodolite has to be used far less, and (rectangular) offsets from base lines and internal measurement of houses are much reduced. Therefore, while a survey may cost us from Re. 1 even up to Rs. 2 per property in a congested city, the cost in large villages comes down to 9 annas including the Enquiry. We can estimate with confidence to do the most complicated village at an all round rate of not exceeding 12 annas per property. We commence with a Theodolite Traverse round the Gaothan in bold legs of about 8 Stations in all, and then we run 2 or 3 minor Traverse lines along main streets to divide the village into 4 or 5 segments or blocks. The Theodolite Surveyor will be occupied less than a week over the whole, and will then hand over to the Plane Table Surveyors 4 or 5 sheets ruled in squares with the Theodolite Stations and legs appertaining to that section plotted upon them. The Plane Table Surveyors will then interpolate all the rest joining the sheets by the boundary-lines of their squares.

6. Enquiry will be made if Section 131 is employed; if not, the Record of Rights will be applied and compiled under Section 135-B. It was applied to the Gujarat surveyed village sites in R. 9211-16. Government have noted in R. 4727-09 that the user of stacking grass, tethering cattle, &c., usually allowed to villagers, should not be allowed to develop into proprietary rights.

The field map should be finished off, inked, traced, and printed and if the population exceeds 2,000, Sanads can be issued as for regular City Surveys (Section 131 being applied to the N. A. lands). When the population is less, then a 'dákhala' like those given in Pot Hissa Surveys should be given to each property holder.

7. When the survey is completed, maintenance must be arranged just as in the case of Cities. Map corrections are to be made by the Circle Inspector or by the Village Accountant, if he is competent: he ought to be trained, since he can also earn frequent fees for maps or copies when once he understands this work. A Record of Rights will be maintained and the Kulkarni will be paid extra allowances for this. The detailed rules under experimental trial will be found in R. 9211-16. The D. I. L. R. is in local control (R. 5249-17). The arrangements have been in operation too short a time for any further opinion to be given on them.

CHAPTER XIV.

Minor Triangulation.

PART I.

[These introductory paragraphs involve too much mathematics for most readers, but are intended for the use of those Officers who have to supervise and understand the principles of such Surveys.]

In Minor Triangulation (so called because the triangles are small enough to be plane and neglect the Earth's curvature; while in Great Triangulation the calculations must be spherical) we lay down a network of fixed pillars of which every adjacent three necessarily form a triangle, and groups of these triangles form polygons covering the whole area with points whose plane co-ordinates can be exactly determined.

It is also permissible (in awkward corners and places where angles cannot be observed all round the horizon) to add to our network of polygons an extraneous triangle to be calculated and plotted after the polygonal system is finished; like the triangle KLM in Fig. XLIV(*a*) when P is invisible from K.

The first step is to observe with the Theodolite at least two, and whenever possible all three, of the angles of each triangle; all the angles which meet at each point being observed at that point; then we examine and adjust these angles to perfect mathematical agreement; then we measure at least one side of the series and calculate the rest. We will now proceed to expand this description.

2. The network of triangles is so laid that it appears to be formed by joining the corners of a polygon to a centre-point within the polygon; next a corner of the first polygon becomes the centre of the second, and so on throughout. Consider the six triangles 1 to 6 in Fig. XLIV(*a*), all meeting at the point O: now what are the conditions of the mathematical exactness of such a polygon? (1) The angles of each triangle must total to 180°; (2) The sum of the angles at the point O must be 360°. Now let us suppose that the six triangles have been so totalled, and that it is found that in triangles 2 and 5 the angles do exactly come to 180°. In 1 and 6 there is an excess of a few seconds. In 3 and 4 there is a defect. These may be called zero, plus, and minus triangles. Next apply the second condition and total the angles at O. Then we shall find perhaps that the sum of the six angles slightly exceeds 360°. Now, we have somehow to adjust these discrepancies. We shall not reduce the vertical angles of triangle 3 and 4 already in defect, but in preference we shall reduce the vertical angles of 1 and 6 enough to bring those triangles down to 180°. If this reduction is not sufficient, we may make a little reduction in the vertices of 2 and 5, and continue until the angles at O total 360°. If after having reduced 1 and 6 to 180° we have still to take off any *more* seconds at the vertices of those triangles or of 2 and 5, we must add equivalently to the base angles; and we must further add a little in the base angles of 3 and 4 to make those triangles also total correctly. Finally, we shall get six triangles which all total to 180° and whose vertices all total to 360°. But these conditions are not enough. Consider Fig. XLIV(*b*) which consists of six triangles; all of their angles total to 180° and their vertices total to 360°, but still their bases do not form a polygon. How can we correct that? In the two triangles ABC, ACD [Fig. XLIV(*c*)], the condition that BC and CD meet at C is this. In the triangle ABC

$$\frac{AB}{\text{Sin C}}=\frac{BC}{\text{Sin A}}=\frac{CA}{\text{Sin B}} \quad \therefore \quad \frac{AB}{AC}=\frac{\text{Sin BCA}}{\text{Sin B}}\text{; and in the triangle ACD}$$

$$\text{likewise } \frac{AC}{AD}=\frac{\text{Sin D.}}{\text{Sin ACD}} \quad \text{Hence } \frac{AB}{AD}=\frac{\text{Sin BCA Sin D.}}{\text{Sin B Sin ACD.}}$$

3. Standing at O and looking towards the bases, we can describe the two angles at the base of each triangle in turn as a right-hand and a left-hand angle. These are marked R and L in Fig. XLIV(*a*). Now if we had a whole series of triangles running round in a ring, coming *back to the side AB again* (which is what we have in the polygon centering at (O), then we should get at last

$$\frac{AB}{AB}=1=\frac{\text{Sin BCA Sin D Sin .....}}{\text{Sin B Sin ACD Sin.....}}$$

and therefore the condition is that the continued product of the sines of all the right-hand angles must be equal to the continued product of the sines of all the left-hand angles. Bringing these sines to logarithms, it means that (3) the sum of the logs. of the sines of the right-hand angles must be equal to the sum of the logs. of the sines of the left-hand angles. The correction of the angles of a polygon to satisfy this condition can of course only be done by taking a second or two from the right to the left side. because we have already fixed the sum of our angles and cannot alter the vertical angles. If we find that the sum of the right-hand angles exceeds that of the left, then we must remember that the sine of an angle increases for an added second much more in a small than in a large angle : and moreover when an angle exceeds 90°, the addition of a second to the angle *decreases* the log. sine.

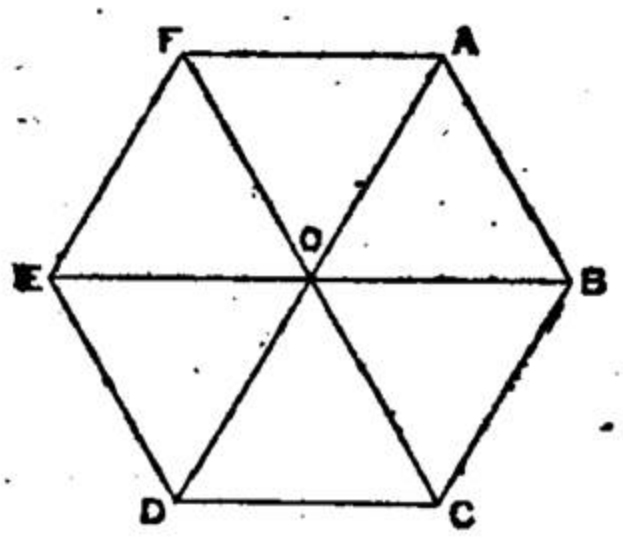
4. So to adjust a *deficit* in total, an addition to a small angle is most effective. If we have any of our base angles greater than 90°, still we may add to that angle and reduce the opposite base angle, and *each* correction will reduce the log. sine. But if all our angles are less than 90°, as is usually the case, then if we have a deficit in the log. sines of the right-hand angles we must add one or more seconds to the larger angles amongst them, always decreasing the opposite (smaller) angles at the base of the same triangle till we get the required agreement. The exact difference which 1″ causes in the log. sine must first be ascertained for each angle from tables and written in a special column. It may be found that there is so much difference that we must correct some of the angles even in a triangle already passed as perfect, and, therefore, our correction of the sums of the angles for conditions (1) and (2) is provisional only till we have also satisfied condition (3).

5. Though our cadastral theodolites cannot usually observe angles of less than 30,″ still we can freely use seconds in the correction work. A correction table from the Triangulation Survey of Kumbharwalan (Purandhar Taluka) is appended together with the calculation of the sides and a sketch of a polygon not drawn to scale: pages 99 and 100.

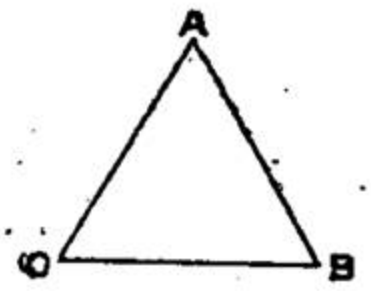
6. When we have got the triangles of one polygon perfectly adjusted, we then take up the next, say, the six triangles centering at Q. But since we have already got the triangles 5 and 4 angularly perfect, we must make *no further corrections* in them, but whatever corrections are needed in the polygon Q must be made in the remaining four triangles, and so on. When we have got the whole of our network angularly perfect, then we proceed to calculate our bases. Here we have no means of making corrections, but since our polygons are perfect, it is certain that our bases must calculate out correctly, if the fundamental base is correctly measured, and if there is any error in this measurement, only a proportional linear error will affect all the others, so that the map will be in no wise distorted. The operation of correcting the angles of a polygonal network is more delicate and requires more mathematics than the correction of a simple Gale's traverse described in paras. 27-28, Chapter II, it is work for a trained computer.

Part II.

7. Chapter II has dealt with Traverses, in which a closed circuit is measured out in successive lengths and bearings, returning to the starting point or origin. In Triangulation we start with one measured side of a triangle and calculate the other sides in such a network of triangles that each triangle has sides in common with other triangles. We can, therefore, start from one measured side and calculate all round the network till we get back to that side; and if our calculations are correct the calculated side at the end of the series will agree with the value we started with. Our angles (may not be perfectly accurate, as observed and corrected) in agreement with the field, but they can and must agree mathematically with one another, and therefore, the calculations of the sides must work back to the initial result. If there is any error in any side so calculated it is due to error in the measurement of the side we started with :



e.g. OA is first measured; then we calculate AB and OB, and from OB the other two sides of triangle OBC and so on till we get to the triangle OFA; then we get by calculation the side OA again and see if it agrees with OA as first measured.



In triangle OAB the side BO opposite to A is called a, AO is b and AB is o. Now by the formula in para. 2,

If o is known ($542\frac{1}{2}$ ft.),

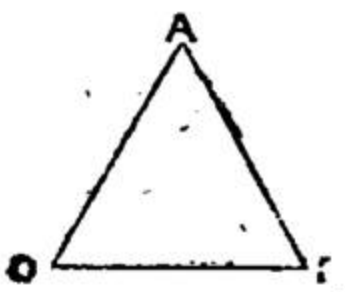
$$b = \frac{o \sin B}{\sin O} \text{ and } a = \frac{o \sin A}{\sin O}.$$

Taking logarithms, Log. b = Log. o + (L sin B − L sin O)

and Log. a = Log. o + (L sin A − L sin O).

Log. o is 2·7343997...and the tabular Log. sins of A, B and O are got from the Tables: but we have already used them and corrected them in the angular adjustment: Therefore we have not to look them up again for this calculation.

8. Therefore the solution of a triangle AOB can be thus written compiling a continuous record similar to the traverse book:—

Triangle.	Angle.	Corrected angular measurement.	Log. Sin (tabular).	Difference.	Log. of sides.	Sides.
1	2	3	4	5		7
	B	57°34′21″	9·9263788	·0471804	2·7815801	AO
	O	49°12′58″	9·8791984	...	(2·7343997)	AB
	A	73°12′41″	9·9810830	·1018846	2·8362843	BO
		180°00′00″				

The figure in brackets (Log. of $542\frac{1}{2}$) was previously known: from it the other figures in column 6 are obtained by adding the differences in column 5. These differences are of course often negative, requiring to be subtracted.

To the next triangle OB is common; so we carry the Log. OB (2·8362843) to its place in the middle line of column 6 of the calculations for the next triangle; and to it apply the differences there got in column 5 and get the sides OB, OC; and so on. The value of Log. OA at the end of the calculations should agree with its initial value (2·7343997) as far as 5 places of decimals. When we have got the correct lengths of all the sides and all the angles we can lay out the co-ordinates of all the traverse stations as we did for traverses in paras. 27-28. For this purpose we can *keep the sides in the form of Logs.*, as it shortens our work in calculating the co-ordinates.

9. It will be seen that besides the triangulation stones there are a number of other points in the map which are determined with great accuracy, and which can be fixed in the field and used both in the original Plane Table mapping and in any subsequent restoration of boundaries or additional detailed mapping. Consider Fig. XLV. It will be seen that every pair of triangles makes a quadrilateral of which hitherto we have only determined and drawn one diagonal, but the other can be drawn on the map and in the field ordinarily. The Surveyor standing at one T. stone and an assistant at the other observing

flags placed over the opposite stones can if the opposite corner of the quadrilateral is visible determine the intersection of the two diagonals with great accuracy, and a flag can be planted upon it. Having thus fixed one point more or less midway between every T. stone and its neighbour, it is even possible to obtain further bases or fixed points as indicated in the sketch. The middle points of each quadrilateral should whenever possible be fixed by the P. T. Surveyor, though they are not demarcated on the ground. He should fix their position with flags, and show these flags on his map, and use the intersection points as stations. Thus it will be seen that no point in his maps will be more distant than about 100 yards at the most from a point determined with great accuracy. There will be of course some positions in which he cannot see across the quadrilateral.

Part III.

Survey Method of Minor Triangulation together with Plane Table.

10. The practical method is founded upon the theory discussed in the chapters on Plane Table and Minor Triangulations.

We are starting, it is assumed, with a village which has never before been surveyed, or of which the old survey is to be discarded.

The first operation is to procure a quantity of stones not *less* than $2\frac{1}{2}$ feet in length of hard durable stone such as black trap and not soft friable stone. In localities where such stone is costly or quite unobtainable, then brick or ferro-concrete pillars must be built at least 2 feet deep into the ground, and 6 inches above the surface with a small slab of stone let into the top. The stones or pillars will be roughly square at the top with a cross or circle ⊙ cut upon them. Taking these stones, we shall first choose sites along or near the village boundary, then in the interior. In choosing the actual site for the stone, we should take the corner or boundary strip of a field or the side of a road or path out of the way of traffic, or a piece of waste land which does not look likely to be ploughed up. Also we must choose positions as open and elevated as possible, so that the stone (or rather a surveying flag placed over the stone) can be seen from the surrounding stones.

11. The object is to construct a network of polygons such as has been described in the last chapter. See Fig. XLVI: first start near the S. W. corner and walk round the village boundary, with the village lands on the right. Put down stones at intervals of about 400 yards on the average; less when there are trees, bushes &c.; more when the ground is very flat and open. Each stone (*i.e.*, the flag marking it) must be visible from the stone before or after. Two assistants at least are needed, of whom one shall stand at the last placed stone, and another shall go 400 yards ahead and see that the proposed site of the present stone is visible. The situations chosen must also be reasonably open to observation from the right-hand side. A ring of stones at suitable, probably shorter, intervals must also be placed round and outside the boundary of the gaothan, hamlets, patches of Forest, or thick garden land, just as round the village boundary. These stones cannot always be exactly on the boundary; at some places trees rocks, water, &c., oblige us to keep some distance off.

In the gaothan, or in a block of very thick gardens, or Forests, we could not see in all directions. Such areas must be left out in the general scheme of triangulation, the network of polygons being carried round them. These gaps will be filled up later by traverse, or if detailed survey in the interior of Forest and gaothan is not required, then it may suffice to fix one or two points in the interior by single legs running up paths, roads or available open patches; or by simple P. T. work.

We thus lay in Fig. XLVI 44 stones round the boundary, inserting pegs and leaving a contractor to bury them properly. Next we lay an inner ring of stones (connected together in the Figure by the red line) about 400 yards, more or less, inside the boundary. Each such stone must see and be seen from several (never less than two) of the stones along the boundary line on either

side. Where land is minutely sub-divided and crops or bushes abound, it may be necessary to reduce the distance possibly as low as 250 yards which should be the minimum limit. This inner ring will furnish the centres of the polygons which are enclosed in squares in the Figure. If there still remains an interior block not covered by the network, we continue laying stones at similar intervals till the whole village is covered with polygons as in Fig. XLVI. A rough hand sketch of the stones put down should be made for the purpose of counting and numbering them, and to ensure that no area is omitted. Place a stake or short bamboo with a bundle of grass tied to it near each stone to help find it quickly in the next operation.

Two stones (1 and 2) have been placed on the opposite bank of the river to enable us to locate the opposite bank on our map: and to afford a sure connexion for the surveys of the two villages, when the village to the south is surveyed.

12. Next, the Theodolite work must be done. Our stones are buried in the ground rising 3 to 6 inches above its surface. It is, therefore, now possible to put up the Theodolite over each stone, and by placing surveying flags over the surrounding adjacent stones (using tripods to plant them exactly over the crosses) to take the angles from each stone to its neighbours in turn all through. The north point (magnetic or astronomic) must also be fixed at a suitable station and rechecked at one or two other distant stations. If the azimuth observations do not exactly tally, a reasonable average should be adopted. In choosing the positions to put down the stones we satisfy ourselves that they were reasonably visible to the Theodolite telescope. (Sometimes a lamp at night, or a mirror flashing sunlight by day enables one to see through bushes or a few trees). If lofty marks must be used owing to obstacles or uneven ground, then care must be taken that they are truly straight and vertical, or in the alternative we must put a white flag at the top and hang a plumb line from the flag, and so fix the upright bamboo or rod that the plummet falls true upon the stone (*see* Fig. X). Theodolite observations can be taken then *upon the white flag*. There will be no measurement of distances between these stations, but the angles measured from each stone will be recorded on a sketch sheet, which will not yet be drawn to scale.

13. Having obtained and corrected (*see* paras. 2 to 6) all the angles, we will next find which of the stones have the most level and even ground between them. Lines crossing rough nalas or up and down hill, or through bushes, are not admissible as bases. We will now suppose that we have obtained by measurement (which must be very carefully made at least twice and in both directions) the distances between the stations joined by a double line in the sketch, Fig. XLVI. We will now call all the Triangulation Stones T. Stones and each measured line a Base. Taking one base we shall then calculate trigonometrically from the known and corrected angles all the sides in the polygons covering that part of the village until we get back to the base.

14. Then knowing all the angles and lengths of sides and the north angle or azimuth of each side, and choosing a suitable zero or origin, we can determine the co-ordinates of every point (paras. 27-28, Chapter II) and can take a large sheet of squared paper and we can plot all these stations correctly on the scale of 400 ft. to the inch. Upon that map we can carefully inscribe the angles and the lengths of each of the sides. In order to assist in finding the position of the stones in the field, we may transcribe nalas, gaothans, roads and so on, into this map from the final map of the village hereafter to be described also we may mark large trees near the spot.

15. Should there be in the vicinity of the village any Great Trigonometrical Station a traverse should be run to that station and back so as to connect with the village series. Or, if the station is visible from two of the stones of the village series the distance (co-ordinates) between which we have calculated, we may content ourselves with taking angles to the station and calculating its distance (*see* two such connexions in the Fig. XLVI).

16. This finishes the Theodolite work, and all the Boundary Marks (or Reference Pillars) for the village are set up. It is most important to notice

that the stones are put down first and observations taken after; not (as alas! often happens) in the reverse order.

17. From the *plotted* map of the T. Stones we now know exactly the dimensions of the village land, and how many sheets will cover it at the scale of 400 ft. to 1 inch. Fig. XLVI is at 800 ft. to 1 inch, and depicts about 800 acres. We therefore divide up the plotted Triangulation map into rectangles of 6″ × 5″ (the surplus being divided into smaller blocks 6″ × 4″, and the projection at K is 2″ × 2″ only), and give them letters A, B, C, &c., and taking sheets on a larger scale, usually 100 ft. (practically 3 chains) to one inch sheets 21″ × 28″ which is a convenient size for printing, plot (*see* para. 49) all the T. Stones and legs connecting them which fall in each sheet, and hand that sheet to the P. T. Surveyor.

18. The Surveyor will put flags on all the T. Stones in his square. He will work as directed in para. 27, Chapter XII. In the course of his Plane Table Survey, he will delineate every field and every sub-division and every road, nala, well, important tree or any other object which he may be directed to include in his map, and also he will show by a distinct sign the position of the T. Stones: thus  VI: the number of the stones is shown in Roman numerals. He will omit the gaothan, since it cannot be done on the 100 ft. scale; but he will show all field boundaries up to the limit of the gaothan area, see below. This area will be left blank on his map.

19. Now, plainly the test of the accuracy of this work can not only be taken in the field by checking measurements of the sides of fields, &c., but also by comparing the common boundary in A's map with that of B's and of E's map. Universal coincidence is impossible, but the *maximum* error that should be tolerated is about 1%, say 1 foot in 100, *see* para. 25, Chapter XII. (There are discrepancies of 300 yards between village boundaries of the old Surveys round Ahmedabad and sometimes of nearly a mile in Kanara forests.) If the error is more than this, it will be necessary to direct that portion of the work to be done again until a closer approximation is obtained. Smaller distances than 1 foot cannot be drawn with pen or pencil on the scale of 100 feet to one inch.

20. It will be seen that in this method any error made in one sheet *in no wise affects the accuracy of any other*. If in spite of all efforts we cannot make the common boundary agree exactly, then the two must be placed together and the final boundary must be drawn midway between the two. But in actual practice we have not found any such serious divergence. If there is strong reason to suspect the error is in sheet B and not in sheet A, then A should be taken as final and B drawn to conform to it.

21. We shall then get a number of sheets about 20″ × 24″ containing all the lands of the village and each capable of being immediately joined to the others. When the numbers of the Survey Nos. or fields and their sub-divisions have been entered on the map, then we can work out areas by the area square (or by multiplication with a scale and offset-scale if great precision is desired) and we can calculate also the areas of tanks, roads, forests, and so on. When the maps are finished we then see whether anyone disputes the boundaries or whether any encroachment on public properties, &c., is disclosed, and (when the map has been passed finally) we can then make a tracing 40″ × 24″ from every pair of sheets showing every field and sub-division, roads, paths, wells, &c., and the position and number of each T. Stone. These tracings are then printed by the Vandyke process which is absolutely accurate and when the whole of the detailed sheets are printed, we join them together on the wall so as to make a continuous map of the village. Then we photograph down to ¼ size or 400 ft. to the inch. This photographed map is not quite so accurate as the individual sheets, *see* para. 133, page 55, but it is intended, like our old village maps, as an index. If we want the exact dimensions of any field we must turn to the 100 ft. sheet.

22. Should there ever be any dispute between landholders about their boundaries, or between them and Government about encroachments, it is at any time possible to determine the exact position of the boundary as on the

day of survey in the following manner :—Fig. XLVII. Draw on the printed sheet the line connecting any two of the T. Stones which passed nearest to the point in dispute. We may possibly find two such lines passing within quite reasonable distance. Then with a scale determine the length of the offset from that liné to the disputed point. This will fix it within two feet. In further confirmation we may also see if there is any adjacent field corner which is by general consent unchanged since the survey. Then we may also take the distance from that point direct to the disputed point by scale on the 100 ft. map. There will be several such possible lines. In this way the boundary can be restored with certainty and its accuracy can be proved. It is not possible for a Plane Table map to be appreciably distorted or falsified, because directly this is done, it will not fit the next sheet, and would be rejected before printing. Therefore, its internal details can be relied upon, *see* also para. 22, Chapter XII, if more extensive restoration is required.

23. Our object is to survey the gaothan if at all to be surveyed on a scale of 25 feet to the inch. In work which is almost wholly Plane Table, the larger the scale the greater the exactitude, *see* para. 28, Chapter XII. We may have to include not only the gaothan proper but also a substantial block of land outside the old gaothan which has been covered with buildings or is in immediate likelihood of being so covered. Also there are lands given up to storing fodder, manure, and so on, which are often divided too minutely to be surveyed on the same scale as the agricultural land. When we speak of "Gaothan," we mean *all* this land occupied by houses, &c., usually forming one solid block. The Surveyors will have carried their surveys of the fields right up to the boundaries of this block, and will have stopped when it gets too congested and intricate, or goes into the gaothan proper. There will then remain a block (exactly defined as to its external boundaries by the 100 ft. maps) which we now have to fill in. We have six main T. Stones, which form a frame round the gaothan, but they are not close enough together, and even though they may now be visible one from the other, at any rate along the outside lines, there is always danger of their being blocked in by new buildings. Therefore, we now take a few more stones which we shall not be able (on account of intervening buildings) to connect up like the T. Stones into a *network*, but shall be obliged to use as the frame work of *traverses*. We place these stones as shown in the diagram (Fig. XLV) just as in City Survey in such a way that each is visible from the one before and after, and usually the line between them runs along some public road or path; because along such a line there is less likelihood of the view being blocked in future by the construction of new houses. In Fig. XLVI we have shown how the gaothan is divided into 5 blocks by means of about 11 additional stones, which will be of much the same size and design as the T. Stones shown. Having put down these stones on the same principles as those followed in City Survey next the Theodolite Surveyor will run 5 traverses across the 5 blocks, and then will plot them on to sheets with LL lines at 25′ to one inch extending to the limits of the land mapped at 100′. Selected Surveyors will map the gaothan in the style adopted for the Gujarat villages (and very much the same as that used for City Survey) using the Plane Table and ordinary offsets and all other methods of filling in the houses and property boundaries and distinguishing built and unbuilt areas; and showing all traverse stones on their maps. They will mark the position of doors, but will not measure their exact location in the side walls of the house or their dimensions. These maps will end at the opposite side of the boundaries of the 100′ maps.

24. When this gaothan work is finished, there will have to be enquiry into the title and the officer making this enquiry will very likely have to deal with the land converted from agriculture in the north of Block II. There may be revenue due to Government on many of these plots.

25. The sheets for the gaothan survey will contain 20 × 24 inch squares with a margin of one or two inches and will join along the LL lines as in C. T. S. A book of the Theodolite calculations, just like a City Survey, will be filed in the Records: showing their tie-lines and how they close on the T. Stones, *i.e.*, instead of proving that the progressive co-ordinates close

round to the starting point or origin, he will show that added to the co-ordinates of the starting T. Stone they close to those of the second stone.

26. On completion of the gaothan sheets, they can all be traced and printed and then joined together and reduced by photography to 100 ft. and then they will exactly fit into the blanks left in the agricultural sheets. When those sheets in turn have been traced and vandyked, the whole including the gaothan can be joined together and photographed down to the single index map at 400 ft. (approximately 12 chains). This reduced map will serve as an index and topographical map; and hill slopes and sharp contours, forests and groves, marshes, rivers and nalas, and the like will be sketched in by a draftsman before photography, so as to improve the general appearance of the map. Names of streets and places, to which roads lead, names of conspicuous buildings or Post Offices, &c., &c., will similarly be marked. The figures giving the survey numbers of all fields will be large enough upon the 100 ft. maps to be clearly legible when reduced to the 400 ft. scale, though the hissa numbers need not be so clear. The boundaries of survey numbers will be shown by unbroken black lines, while the boundaries of hissas will be dotted. Of course the scale and date of survey and signature of officer in charge will all be printed out on the index maps as well as on the individual sheets, which will also be signed by the Surveyor: and all sheets are plotted with the North at the top. Fig. XXIV (*a*) shows what the gaothan looks like when *twice* reduced from original sheets 25 ft. to one inch to one-sixteenth of that size. With a magnifying glass the numbers, and built and unbuilt areas, and even doors of every property can be discovered; though this reduced map is not intended to show more than the general features of the gaothan.

27. In rough or mountainous country the laying out of the T. Stones will be exactly as before, only remembering that if we measure 400 yards up a steep hill, we must then add a substantial amount in proportion to the slope in order to cover a horizontal distance of 400 yards. In all survey we deal with the dead flat horizontal distance only. It might seem that the owner of a hillside really possessed an area larger than the horizontal plane which would cover his land. But this is not really so, because one cannot grow more trees or blades of grass on a hill slope than can be grown on the corresponding horizontal plane.

28. When we have set down the T. Stones and taken the angles we can then calculate the true distances as before, provided only that we are most careful that the bases we measure are chosen along level ground and not up or down the slopes. In the triangle ABC (Fig. XLVIII) if A is down in a deep hollow, while B and C are high above it, but the distance BC is correctly measured, then the calculated horizontal length AB and AC will be exactly right, though the directly measured distance AB would be a great deal more than the true horizontal. (This statement is of course correct when we disregard, as is always done in these cadastral surveys, the difference between spherical and rectangular co-ordinates—a difference which is negligible over such distances as we are dealing with). If we are absolutely obliged to measure any base between T. Stones up a distinct slope, then we must call in the Theodolite and ascertain the angle in the vertical plane, and reduce the measured length to the true horizontal length.

29. Plane Table work is not affected by slopes at all, provided we do not measure distances between stations by tape or chain up or down a slope. Therefore, in hilly ground we should resort more frequently to the method described in para. 6 (2), Chap. XII, for getting new stations by intersections, and not by direct measurements. Thus in Fig. XLIX we get from the two stations AB two new stations F and G, and from these again another pair at K and L. These may be up the steepest hill slopes imaginable, and yet there will be no deviation from truth in the positions obtained, so long as we never use the tape or chain except between A and B. Whenever possible we recommence our P. T. work from the T. Stones.

30. It is in such rough and mountainous ground that the Plane Table comes out so much more accurate than the Cross Staff. It is no use warning a Cross Staff Surveyor that he cannot measure accurately up and down slopes or through impossible ground. He has either got to do it, or else give up the measurement altogether. Now, consider Fig. L; we want to ascertain the distance AC and BD when there is between them an impenetrable wood and an unfordable river and ravine as shown. With the Plane Table this is a perfectly easy proposition. We have only got to find any two stations X and Y as in the diagram, in order to be able to plot on our map exactly the distances ABDC. Another instrument for the same purpose is the Tacheometer, but it is too expensive for our field surveys.

31. Whenever there is in the village a temple or tower or any other conspicuous mark either on the flat ground or on an elevation, always fix its position exactly by extra angles from at least two of your T. Stones. If it is a tower or hilltop, then some precise point on it must of course be fixed and described. You cannot always put a stone there, but the mark itself being permanent does not require a stone: and in restoring boundaries or refixing a missing T. Stone, the exact position of such a point will often be useful.

32. In this system we do not rely upon boundary marks to individual fields for determining and maintaining the boundaries. In cultivated lands, boundary strips, hedges and distinctions of crop are always sufficient to distinguish fields from one another, and with the detailed Plane Table map of the boundary of every hissa in one's hand, it is easy to pick up the individual field whenever required and detect any appreciable change or encroachment. But this is true chiefly where there is more or less continuous cultivation. It does not apply so readily in stretches of waste land where survey numbers whether occupied or not occupied show no difference or distinction one from the other. One sees this often in Northern Gujarāt, and of course it may happen anywhere. In such circumstances, and also where there are many small numbers very similar in shape and appearance, the officer in charge of the Survey should select in addition to the T. Stones in every sheet a few extra marks at important trijunctions, or at other points which might take time to identify in the inspection of fields. He can upon the Plane Table map put a distinctive mark such as a double circle at the places perhaps 5 or 6 in number which he may select in the sheet for the erection of such stones.

33. The best kind of mark to erect is a cairn (buruz) of loose stones where obtainable; elsewhere conical mounds of earth (where it is not too soft); where neither of these are possible specially cut stones, or pillars of brick and lime; or perhaps ferro-concrete, should be prescribed. No other boundary marks need be recognised or maintained. But between cultivated lands in different occupation an unploughed strip or distinctive ridge must be maintained and declared to be a boundary mark under Section 121, L. R. C., unless a fence, hedge wall, or other clear continuous mark exists (*see* paras. 20-22, Ch. XII, for the use of Plane Table maps in such boundary restoration work). These cairns or cones will also be marked on the map, and the landholders should be charged with their maintenance. They are intended to assist people who are not good at map reading and to satisfy rayats who think that such marks are a better protection. But also, if found intact, they will save much time in settling disputes and in amending the maps for any alteration. There is of course not the slightest objection to the rayats themselves putting up extra marks, stones, mounds, ridges, or whatever they like in addition to the T. Stones. They must not, however, be cut or numbered to imitate T. Stones.

34. Our Old Revenue Surveys (Joint Report of 1847) proceeded upon the assumption that few changes would take place in the boundaries of S. N. which they considered represented practically permanent divisions of cultivation. They, therefore, demarcated the corners and bends of the fields, but left no other permanent marks. Even their traverses, which went round one or several village boundaries, were not demarcated and so cannot be picked up again. When, therefore, S. N. boundaries change and the demarcating stones, &c., are pulled up, there remained no means of restoration. It is true that

not very many S. N. do change, but in the Konkan they certainly change rapidly. In one block of seven Mahad villages we found 58 per cent. of the S. N. materially altered after 50 years. In the Deccan and Gujarat, even if only 5 per cent. changed in a century—the true figures would be certainly higher—still the law is not made for the 95 men who are honest, but for the five who are not. Our system must be able to cope rather with the five which change than the 95 which do not. Now a Plane Table map, based on triangulated points demarcated and maintained, not only can be used to restore, but can also very readily and easily be *altered to conform to the changes of each generation.* The difficult technical work is the frame work of T. Stones; any instructed Talati can repeat the interpolation, in any part or the whole of his village, if extensive changes require it. There is a steady stream of subdivision and an equal and opposite current of amalgamation. We must not assist the one and oppose the other. As often as one holder becomes possessed of two adjacent plots formerly separately held, but not naturally segregated (as by a water course or a sharp difference of level, &c.), we must amalgamate; and this will counteract the continual subdivision. But a system of rigid survey numbers admits of unlimited internal subdivision, but not of that remodelling which involves amalgamation. We require at all times to be able to present a map of the present state of holdings, just as it would have been prepared if the Original Survey had been made to-day. We cannot keep the old field limits rigidly fixed as they were set up a century ago. Even the Original Survey contemplated extensive alterations and amalgamation of holdings at each Revision Survey. But the old style of tippans and boundary marks did not admit into our Land Records the degree of elasticity offered by the system of triangulation with Plane Table interpolation.

35. *Extract paragraphs 8 to 12 from the General Report of the Revenue Survey operations, Upper Circle, Bengal, for 1866-67, by Col. Gastrell (Surveyor General), referred to in para. 1 and 5 of R. 1444-69.*

"(8) In my report on the Punjab Surveys, and in that of the North-West Provinces, I have noticed the advantages to future administrations, and to the public generally, which would follow the introduction of the Madras system of permanently marking, not only all village triple junctions, but all Theodolite stations by platforms of masonry, or by stone pillars, or by a combination of both.

"(9) In Madras, the Act No. XXVIII of 1860, which received the assent of the Governor General in Council on the 29th June 1860, provides amply and fully in every particular for the establishment and maintenance of boundary marks, &c. Were the provisions of this Act extended to all India, it would do more to render all future Surveys of India lasting and imperishable than any steps yet taken. It is precisely what all professional Survey Officers have long yearned for, and I strongly urge on the consideration of the Government of India its extension throughout the country.

"(10) Much has been written and urged on this behalf, and first in the Punjab, then in the Central Provinces and in Oude, and now in the re-survey of the North-West Provinces, masonry platforms have been built, or are in course of erection at all village triple junction stations. In the Central Provinces, in addition to this, every bend of boundary has been marked,—in most districts, if not in all—by some stone pillars, and in the Punjab disputed boundaries when decided were permanently marked by masonry pillars.

"(11) In Bengal and in the old North-West Surveys, however, no marks were erected, and the consequence is, that except for area and the reproduction of maps and plans, the records of the former surveys are nearly useless. Scarcely a trace of their progress has been left behind them. Here and there a pillar has been erected by a Surveyor to mark the spot where an astronomical observation has been made, or marks have been made on buildings to enable the Great Trigonometrical Survey to effect a junction with our operations hereafter, but boundaries have not been marked, and the consequence is, that re-laying a boundary from the old data with accuracy is in all such cases an absolute impossibility. This is why I would urge a law being established

for all India, rendering it imperative upon all landholders to erect permanent marks from which the Original Survey boundaries could be simply and certainly re-laid, without calling in the aid, each time of doing so, of expensive and costly professional operations.

"(12) Slight modifications may possibly be required to render the Madras Act applicable to the different landed interests of India, but if the same results be ensured throughout the country, they would increase the value of the Survey ten-fold, and confer a lasting blessing on the people. This Act embodies, I conceive, all that is required to ensure the permanence of our labours."

36. Thus the Surveyor General advocates the erection of a pillar at each village boundary trijunction, and at (important) bends: and all Theodolite Stations. The theoretical reasons are unimpeachable, but practically it would be found that many such pillars would be so located (in forest, ravines, river-beds &c) that long sight-lines over the village lands are not obtainable; moreover, in large villages there would be miles of intervening hills and woods between pillars, and it is not prescribed how the Theodolite Stations should be chosen or whether they would be confined to traverses along the boundary, or distributed over the area under Survey. The method described in this chapter has greater theoretical merit and avoids the practical weaknesses.

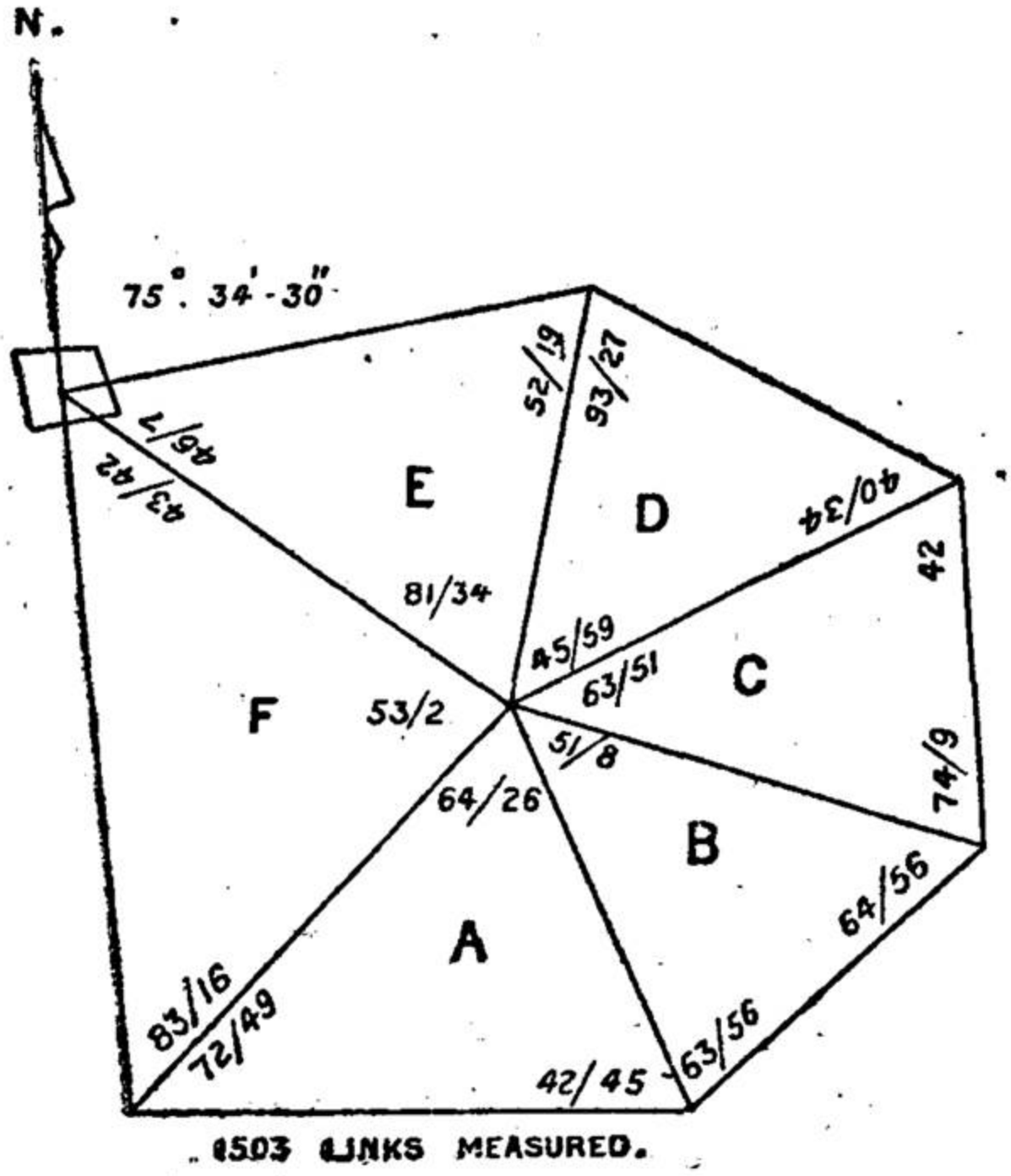
Centre.			Left.					Right.					Sum of corrected angles.
Tri-angles.	Observed angles.	Correction.	Observed angles.	Log. sine.	Log. difference for + 1".	Correction.	Difference for correction.	Observed angles.	Log. sine.	Log. difference for + 1".	Correction.	Difference for correction.	
A	64°26′		42°45′ — 31″ 42°44′29″	9·8317423 — 704 9·8316719	22·7	— 30″ — 1″	— 681 — 023	72°49′ + 31″	9·9801690 + 202 9·9801892	6·5	+ 30″ + 1″	+ 195 + 7	180°
B	51°8′		64°56′	9·9570397	9·8	...	...	63°56″	9·9534134	10·3	...	...	180°
C	63°54′		42° — 0′50″ 41°59′10″	9·8255109 — 1170 9·8253939	23·4	— 30″ — 30″ + 10″	— 702 — 702 + 234	74°9′ + 50″	9·9831661 + 300 9·9831961	6.	+ 30″ + 20″	+ 180 + 120	180°
D	45°59′		93°27′ — 30″ 93°26′30″	9·9992122 + 39 9·9992161	— 1·8	— 30″	+ 039	40°34′ + 30″	9·8131354 + 738 9·8132092	24·6	+ 30″	+ 738	180°
E	81°34′		46°7′ — 1′ 46°6′	9·8577863 — 1218 9·8576645	20·3	— 30″ — 30″	— 609 — 609	52°19′ + 1′ 52°20′	9·8983968 + 978 9·8984946	16·3	+ 30″ + 30″	+ 489 + 489 978	180°
F	53°2′		83°16′ — 30″ 83°15′30″	9·9969941 — 75 9·9969866	2·5	...	— 075	43°42′ + 30″	9·8391041 + 661 9·8394702	22·03	+ 30″	+ 661	180°
				59·4682855 — 3128 ·4679727			—3167 + 39 —3128		59·4676848 + 2879 ·4679727			+ 2879	

Triangle.	Angle.	Corrected degrees.	L. Sin.	Difference.	Log. of side.	Sides.
A	Left	42°44′29″	9·8316717	—·1235752	3·0533838	1130·8
	Centre	64°26′	9·9552469	...	*3·1769590*	*1503*
						by measurement.
	Right	72°49′31″	9·9801892	·0249423	3·2019013	1590·8
B	L	64°56′	9·9570397	...	3·2019013	1590·8
	O	51°8′	9·8913191	—·0657206	3·1361807	1368·3
	R	63°56′	9·9534134	— 0036263	3·1982750	1578·6
C	L	41°59′10″	9·8253939	...	3·1982750	1578·6
	O	63°51′	9·9531038	·1277099	3·3259848	21.8·3
	R	74°9′50″	9·9831961	·1578022	3·3560772	2270·3
D	L	93°26′30″	9·9992161	...	3·3560772	2270·3
	O	45°59′	9·8568121	—·1424040	3·2136732	1635·6
	R	40°34′30″	9·8132092	—·1860069	3·1700703	1479·4
E	L	46°6′	9·8576645	...	3·1700708	1479·4
	O	81°34′	9 9952785	·1376140	3·3 76843	2080·9
	R	52°20′	9 8981944	·0408299	3·2109502	1625·2
F	L	83°15′30″	9·9969866	...	3 2109002	1625·2
	O	53°2′	9·9025389	—·0944477	3·1164525	1307·5
	R	43°42′30″	9·8394702	—·1575164	3·0533838	1130·8
A	L	42°44′29″	9·8316717	...	3·0533838	1130·8
	O	64°26′	9·9552469	·1235752	3 1769590	=1503·000
	R	72°49′31″	9·9801892	·1485175	3·2019013	1590·8

From the lengths of sides and angles, the co-ordinates can now be obtained, if the North angle is fixed.

The log. sines in this calculation should be taken direct from the Table, and then compared with those in the preceding correction form as a check over arithmetical errors.

Polygon No. 1 of Kumbharwalan (Saswad); surveyed with an old 4-inch theodolite not reading closer than 1 minute.



III.

Duplicate of Notice.

No. (in Enquiry Register)

Date—

Served on—Mr.

Signature of recipient.

Notice of Enquiry.

(To be served under Section 189, 190, L.R.C. upon parties believed to be interested and affixed to the land and at Municipal Office or Chavdi.)

To

Mr.

Whereas the plot (here describe)
is claimed by Government or Municipality
by Mr. against Government or the Municipality
Notice is hereby given that an enquiry will be held by me in order to decide the said claim :

You are hereby required to attend before me either in person or by a duly authorised agent at o'clock of the noon at the site in dispute (or) at my office situated in
on the day of at which time and place an enquiry into the same claim will be made.

And you are hereby required to produce before me at the above named time and place any evidence you may wish to be heard.

If you fail to attend in person or by a duly authorised agent in pursuance of this Notice the above mentioned claim will be decided in your absence and you will not afterwards be entitled to be heard with respect thereto, except in an appeal filed within 60 days or in a civil suit if filed within one year from the date of my decision.

Dated this day of Enquiry Officer.

IV.

Notice (under Section 189, L.R.C.).

To

Mr.

A Notice of enquiry was served on you on in which you were requested to be present with documentary evidence, &c. at house No. Street . As you were not present at that time and place a *further Notice* is hereby given to you to be present at the above mentioned place on date at hour . If you fail to attend, the enquiry and decision regarding your ownership of the above mentioned property will be made in your absence.

If it should prove indispensable to compel your attendance or the production of your documents, further compulsory process may be resorted to, according to law, and you will be liable, under the Penal Code, for disobedience to this order.

Date Enquiry Officer.

V.

Public Notice (to be affixed on open land).

This plot of waste land described below is claimed by Government. If any person has a right of ownership or any other right over it he should appear with any documentary or other evidence he may possess regarding his rights over the said land before the Enquiry Officer at his office situated in . An enquiry will also be made on the spot, and decision given as to the ownership or other rights over the land. If no person having a right of ownership or any other right over the land appears before the Enquiry Officer at his office, or in the local enquiry and establishes his claims the said land will be treated as Government property.

Dated Collector.

Description of land.

Street House No. (in the Municipal Register) or otherwise known as the boundaries of which are as under :—

To the North To the East
„ „ South „ „ West

VI.

Form of Enquiry Proceedings : City of

Chalta No. , Municipal No. , Tikka No.

Parties present :—

Parties absent, though served with notices, as shown in Enquiry Register and counterfoils of Notices.

Date of enquiry— Time— Place—

[The substance of the statements of Parties, Witnesses, and notes of Exhibits should be recorded : and signed by E. O : then the decision : and then a note of the service of decision.]

Statement of the Party.

Tikka No.

Chalta No.

Municipal No.

Street—

Signature of receiver—

Signature of server—

Date of serving Notice on—

Person

Property.

VIII.

Notice of Enquiry decision City Survey, under Section 37 (2) of the Land Revenue Code or 50-A of the District Municipal Act.

Whereas in accordance with a Notice duly issued and served, an enquiry was held by me on

and an order was passed on

Notice is hereby given to all persons concerned and to

Mr.

that my decision and order is that :—

(1) The plot is declared to be the property of Government / Municipality and all your claims to it have been rejected.

(2) Your claims to the plot have been admitted and the boundaries as laid down in the map in my office which is open to your inspection are confirmed.

(3) Your claim has been partly admitted as follows :—

If any person desires to appeal against this order, he must appeal in the prescribed manner to the COLLECTOR within 60 days from the date of the said order. Unless it be lodged within one year from the date of the final decision of such appeal, or if no appeal is lodged then from the date of this order, no Civil Suit can be instituted in any Court to set aside or vary the effect of this order.

Dated this day of

Enquiry Officer.

XII.

Notice (Section 133, L. R. C.).

To

The City Survey Sanad of your marginally noted property (ies) situated in

street in the town of

City Survey No.
Old Municipal No.
Survey Fee. Rs. As. .

$\frac{\text{ha}^{\circ}}{\text{are}}$ ready. You are hereby requested to pay the marginally noted survey fee (s) and take away the Sanad (s) from the office of the undersigned on (date)

If you do not apply for the Sanad (s) and pay the survey fee (s) within six months from the date ( ) of the Public Notice issued by the Collector, you will be liable to an additional fee not exceeding Rupee One for each Sanad.

Dated

Officer in charge, City Survey Office.

XIII.

Day and Receipt Book of Sanads.

[Standard Form No. R. F. 155.]

Can be had at Yeravda Prison Press in books of 20 pages containing 100 forms.

Serial No. and Date.	No. in Register.	Name of payer.	Amount.	Date Received from Mr. Receipt No. I. (in words) Rupees annas Rs. As.				
				Sanad No.	Fee Rs.	Sanad No.	Fee Rs.	
I								Receiving Officer.

XIV.

Diary of Traverse Surveyor *Town*

District *for 10 days ending*

Date.	Stations laid down.	Observed in field.	Calculated in Office.	Mapped in General Traverse map.	Transferred to detail maps.	Remarks.

XV.

Diary of House Measurer *Town*

District *for*

Date.	Sheet No.	No. of squares completed.	No. of properties measured.	Remarks.

XVI.

Progress Report of Enquiry Work *City Survey,*

for the month of *191.*

No. of working days.	No. of cases completed.	Of those completed			Remarks.
		Number disputed		Number undisputed.	
		In which corrections were necessary.	In which corrections were not necessary.		

FORM I.—MAINTENANCE.

Cross Reference Sheet.

S. No.	Brief nature of changes.	Other S. No. under which papers can be found.	Register or other document in which particulars are to be found.

FORM II—MAINTENANCE.

(A separate notice for each Survey No.)

From the (Secretary) Municipality.

To the Officer in charge City Survey.

Begs to intimate that the following change has been discovered or has resulted from orders issued or sanctioned by the Municipality :.

S. No.	Nature of change.	Reference to Municipal Records.

Municipal intimation.

Survey No.

Nature of change—

Reference to Municipal Records.

Date of despatch to City Survey Office.

Municipal Officer.

FORM III—MAINTENANCE.

Diary of Maintenance Surveyor *City of*

for fortnight ending

Date.	Sheet No.	Properties visited.	T. Stones checked.	T. Stones replaced.	Properties examined or measured on review.	Properties measured on application or officially, &c.	Changes made in Register.	Changes made in map.	Other office routine work performed.

List of Figures.

POONA: PRINTED AT THE YERAVDA PRISON PRESS

FIG. I. Pages 6 & 11, Paras 17, 26 & 27.

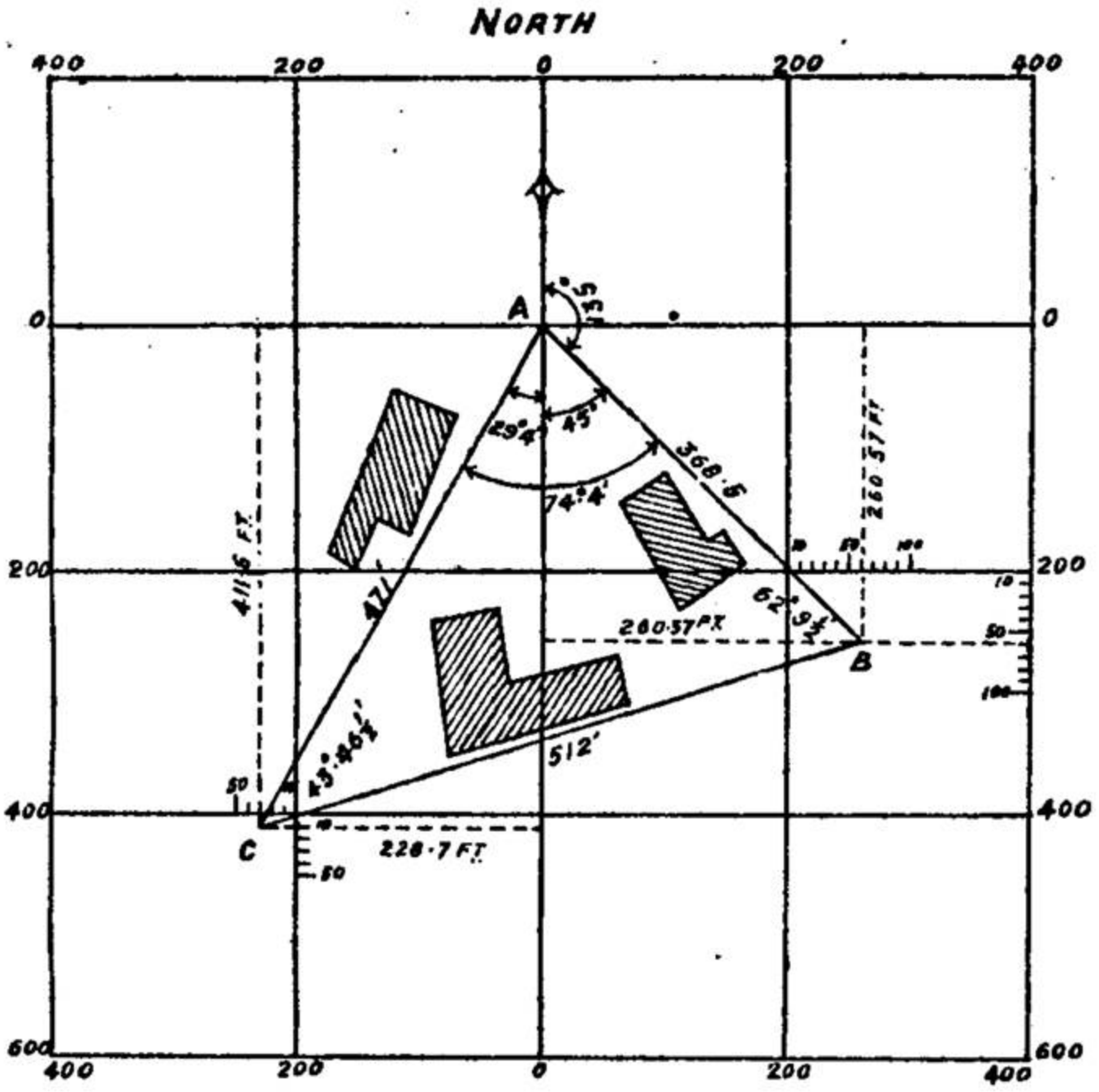
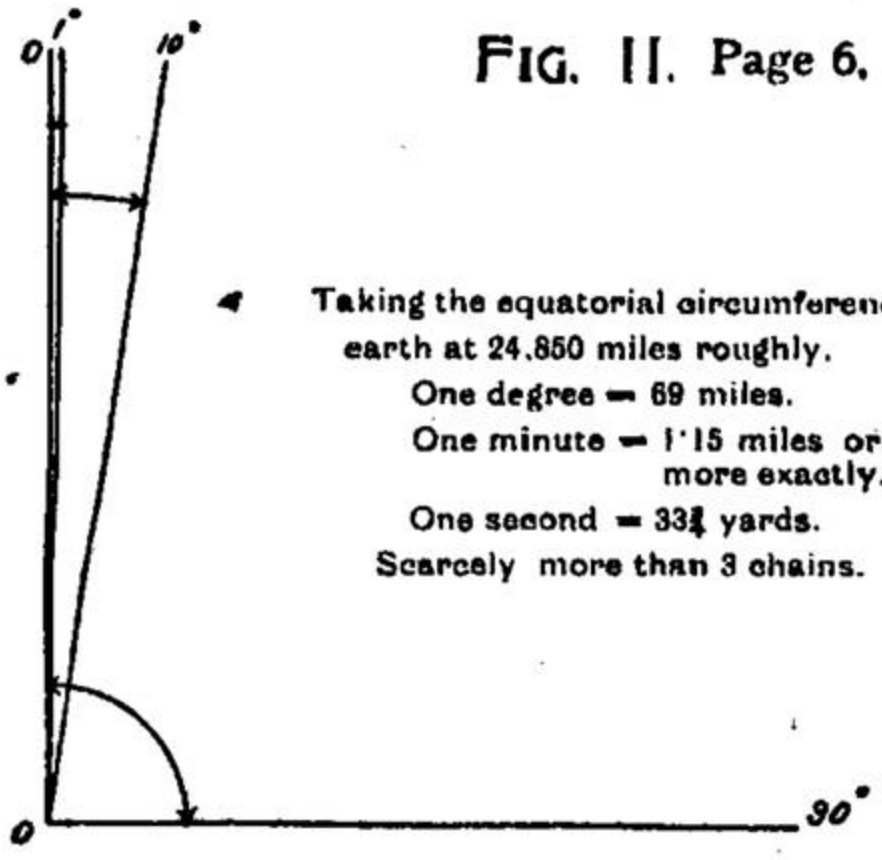


FIG. II. Page 6, Para 18.



Taking the equatorial circumference of the earth at 24,850 miles roughly.

One degree = 69 miles.

One minute = 1·15 miles or 6086 ft. more exactly.

One second = 33⅓ yards.

Scarcely more than 3 chains.

FIG. III. Page 10, Para 23.

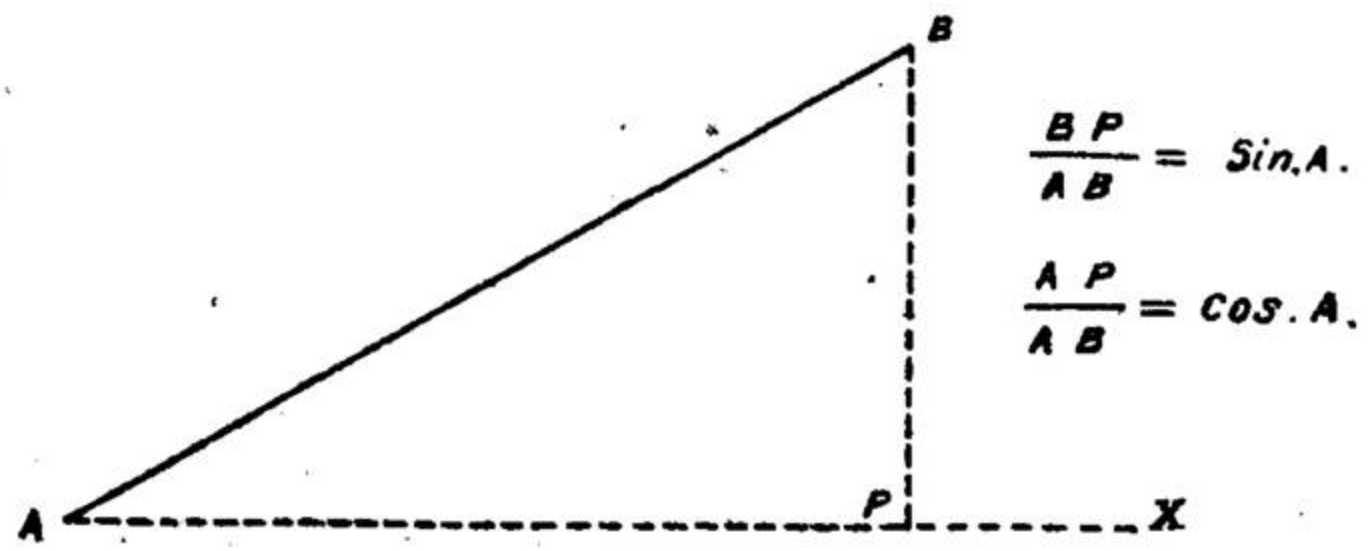


FIG. IV. Page 10, Para 24.

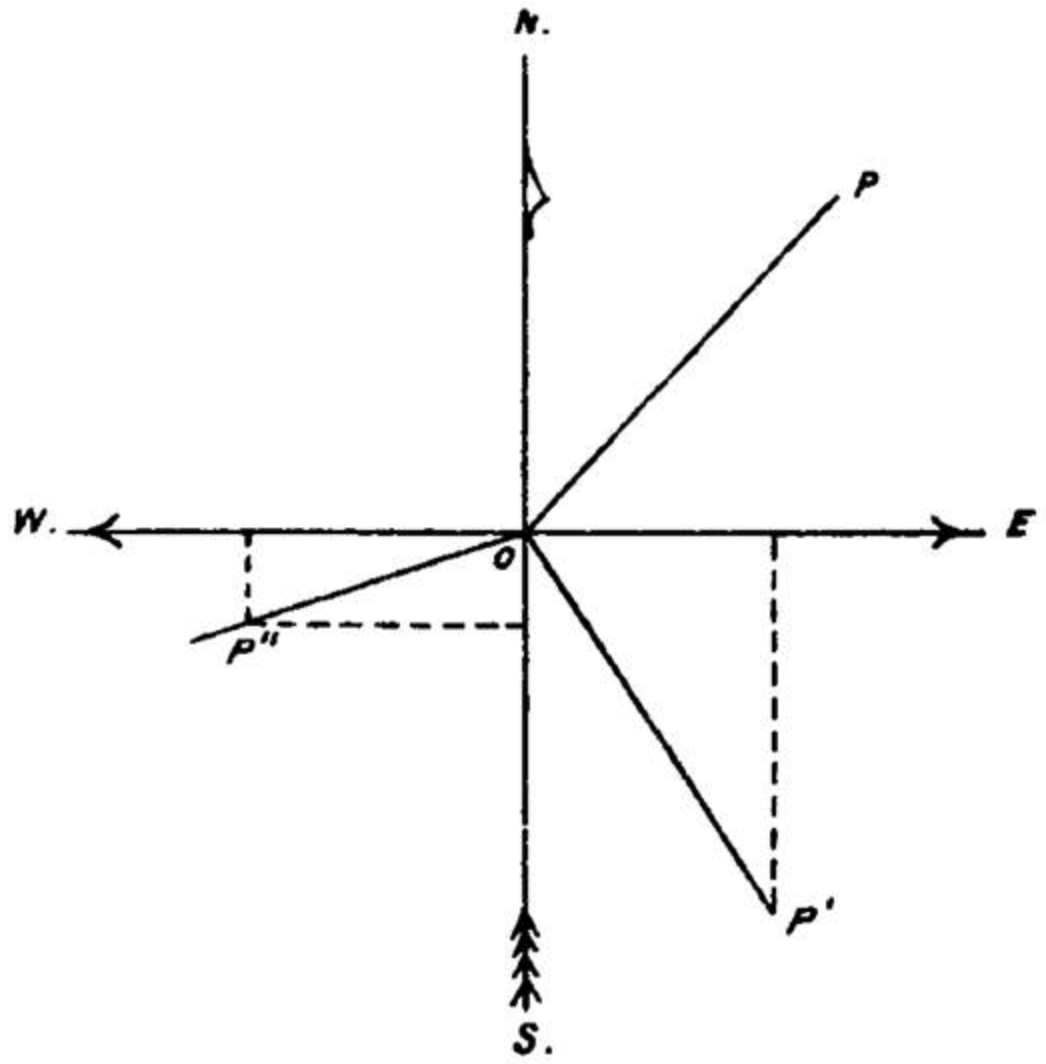


FIG. V. Page 12, Para 30.

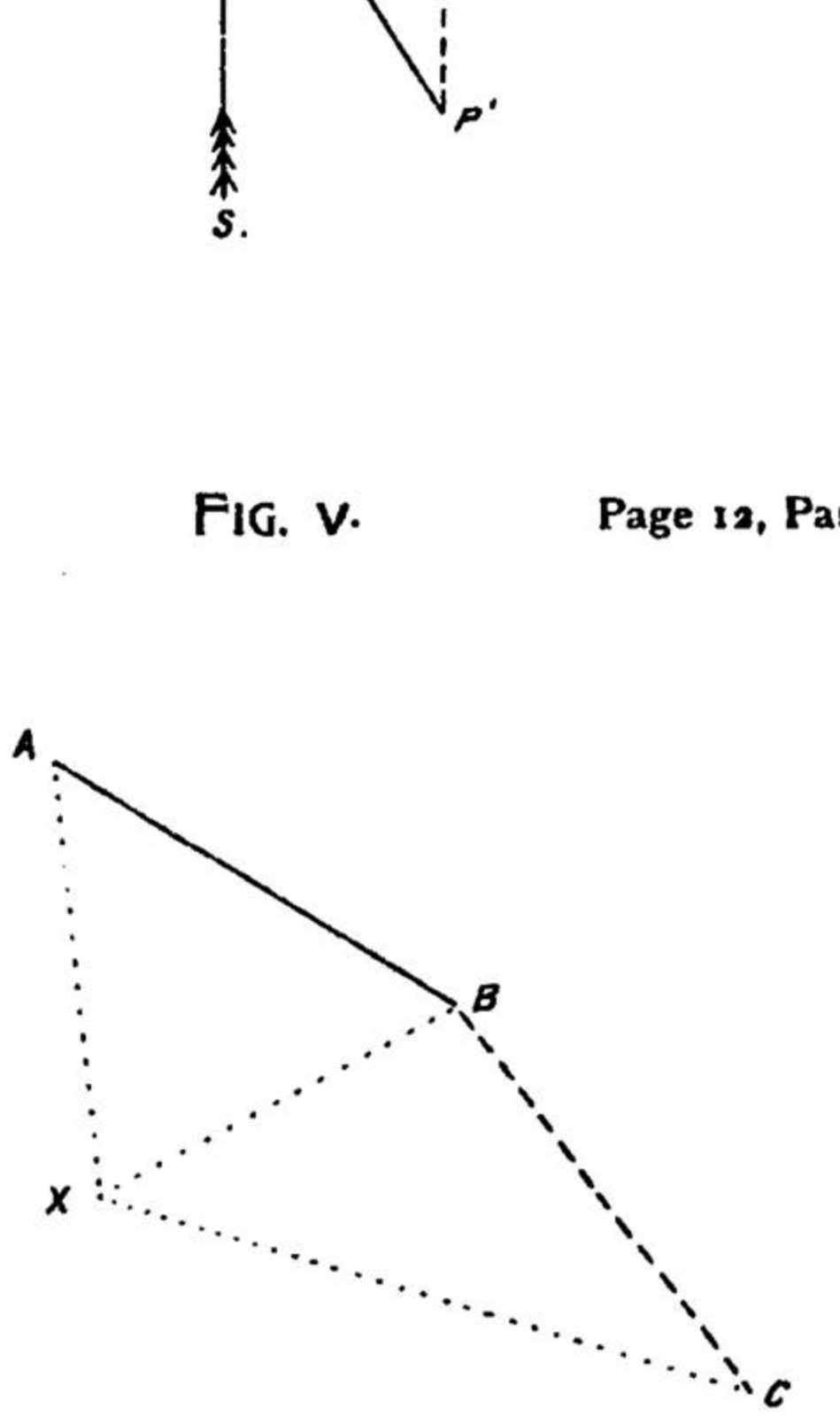
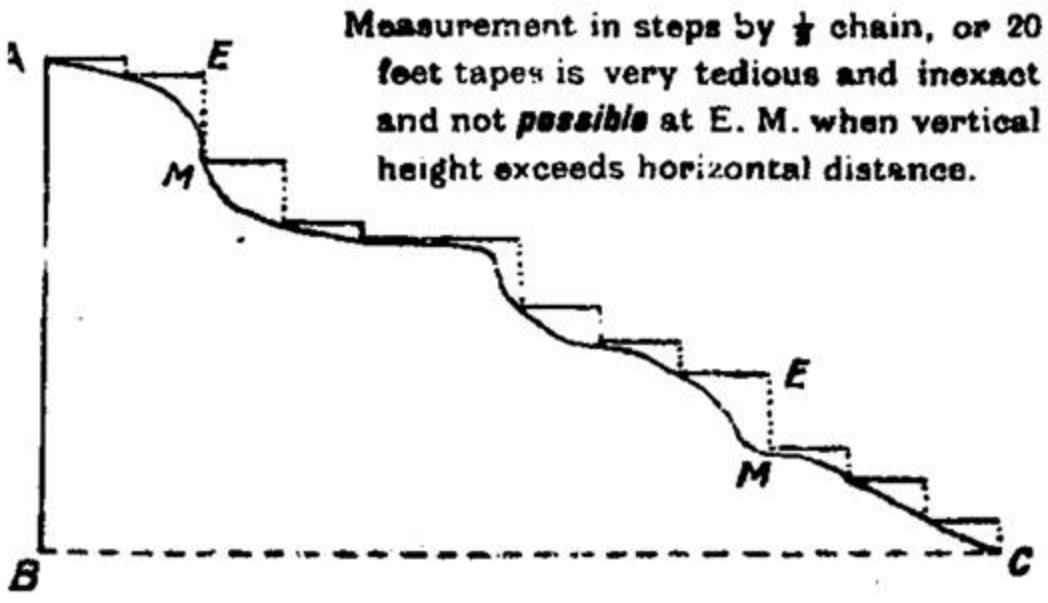
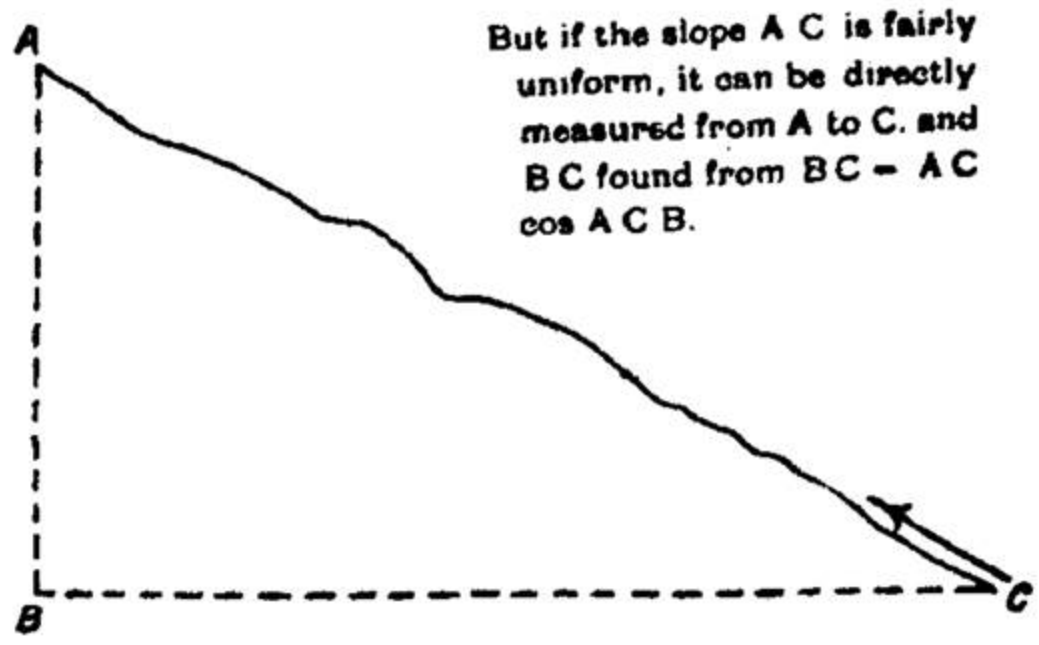


FIG. VI. Pages 13 & 24, Paras 30 & 56

Slope Measurements.

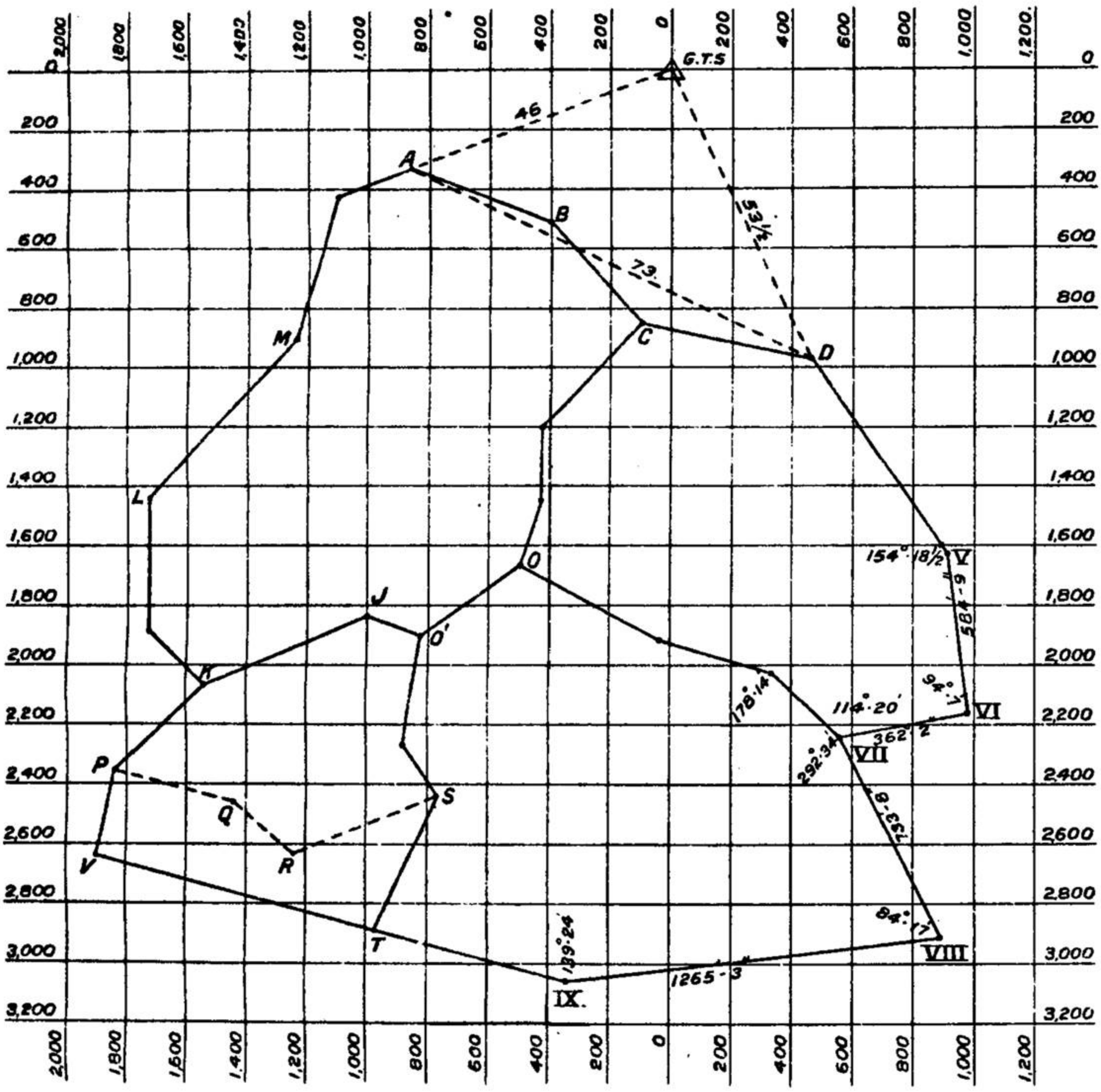


Measurement in steps by ½ chain, or 20 feet tapes is very tedious and inexact and not ***possible*** at E. M. when vertical height exceeds horizontal distance.



But if the slope A C is fairly uniform, it can be directly measured from A to C. and B C found from B C = A C cos A C B.

Fig. VII. Pages 15, 18 & 19. Paras 36 & 49,



BLOCK EXTRACTED FROM DHULIA. FIG. VIII (A). Pages 15 & 18. Paras 37 &

○—Stations actually put down 18.
●—Stations requisite ..... 4.
———Bases built on traverse by joining points fixed on the legs or upon other bases; or B by the intersection method (3), and A by offset from the traverse leg, method (2)..... para 48.

518 A 520 D

M A D L O

518

2072 II.
2071 2070
2069
2068
2067 2066
2065
2064
2063
2062
2061
2060
2059
2058

C H A M B H A R G A L L I

2184 2185 2186 2187
2188
2194 2193
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2215 2214
2216
2217
2218
2219
2220
2221
2222

2189 2190 2191
2192
2211
2210
2209
2208
2207
2206
2205
2213
2212

A 521
B 522

LATRINE 2223

L.P.

537 536 523 524

R O A D

2057
2056
2053 2052
2051 II.
2048 II
2047
2041
2040 II
2039
2031
2030
2029
2028
2027
2026 2025 2024

L.P.

No. 7

2055
2054
2050
2049
2046
2045
2044
2043
2042
2038
2037
2036
2035
2034
2033
2032
2020
2019
2018
2017
2226

LATRINE 2224

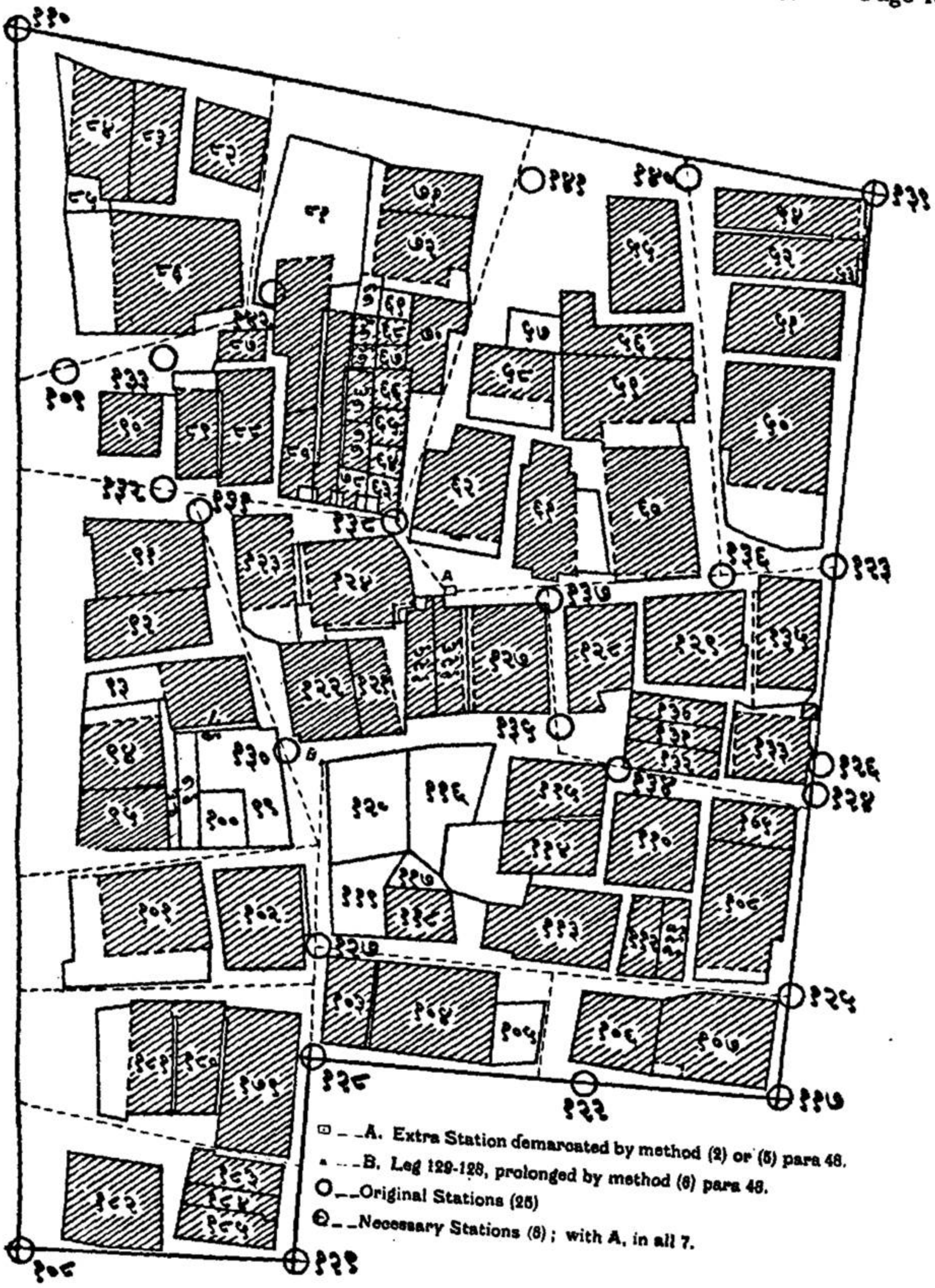
534 533 535 532

2225

L.P. 242 531 530 529

BLOCK EXTRACTED FROM THANA. FIG. VIII. (B).

Page 18, Para 48.



□ - - A. Extra Station demarcated by method (2) or (5) para 48.

▲ - - B. Leg 129-128, prolonged by method (6) para 48.

○ - - Original Stations (25)

◎ - - Necessary Stations (6); with A, in all 7.

FIG. IX. Pages 16 & 17, Paras 39, 42 & 43.

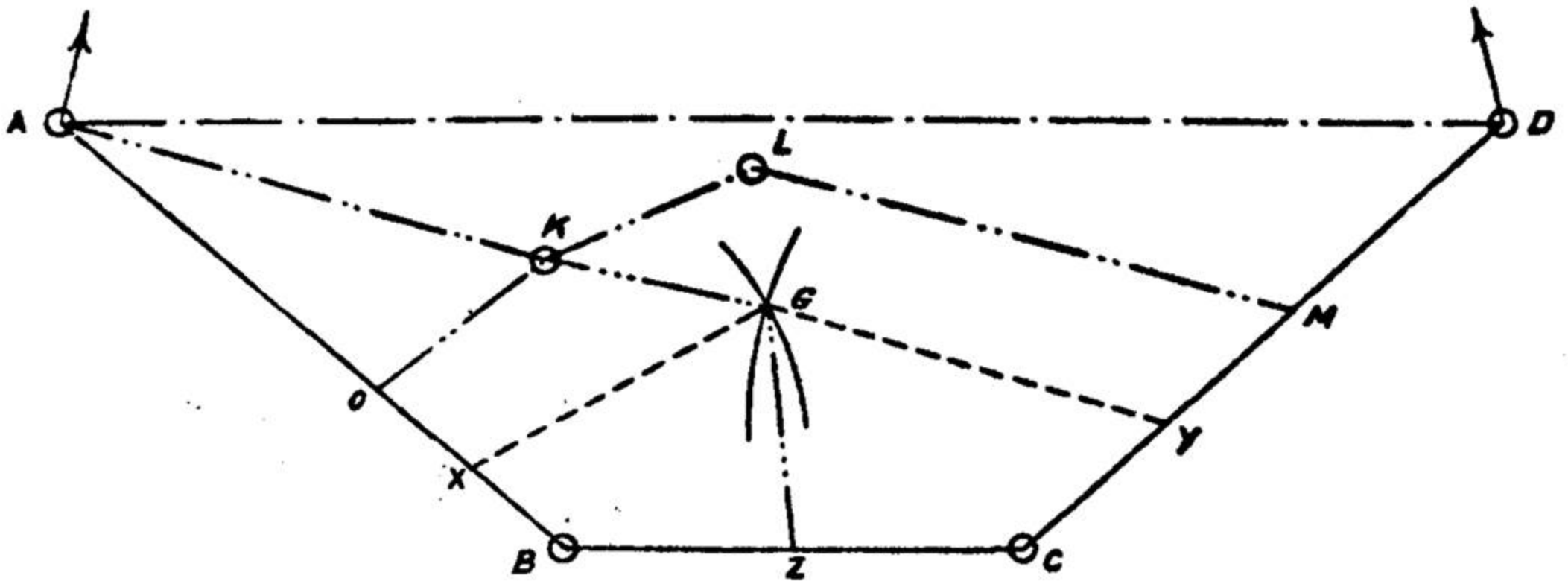


FIG. X. Page 17, Para 46.

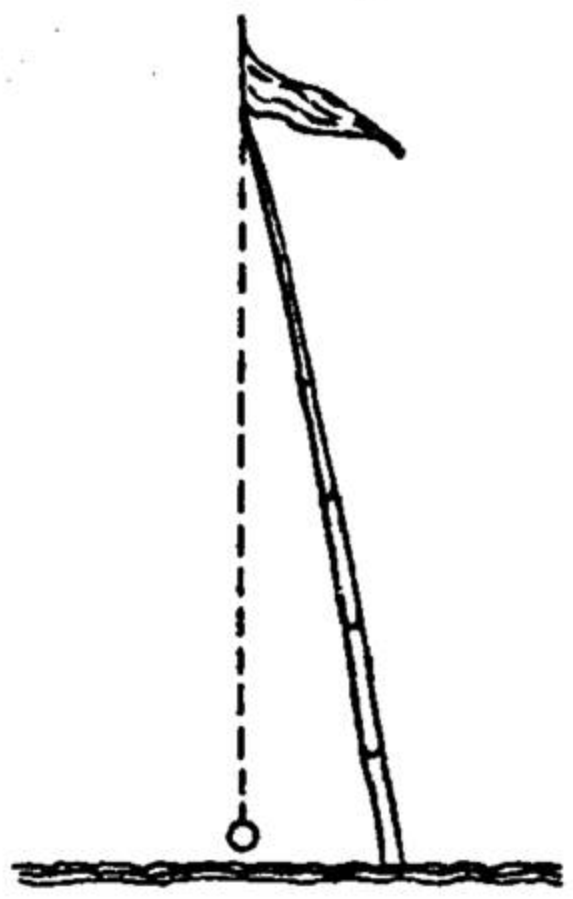


FIG. XI. Page 17, Para 46.

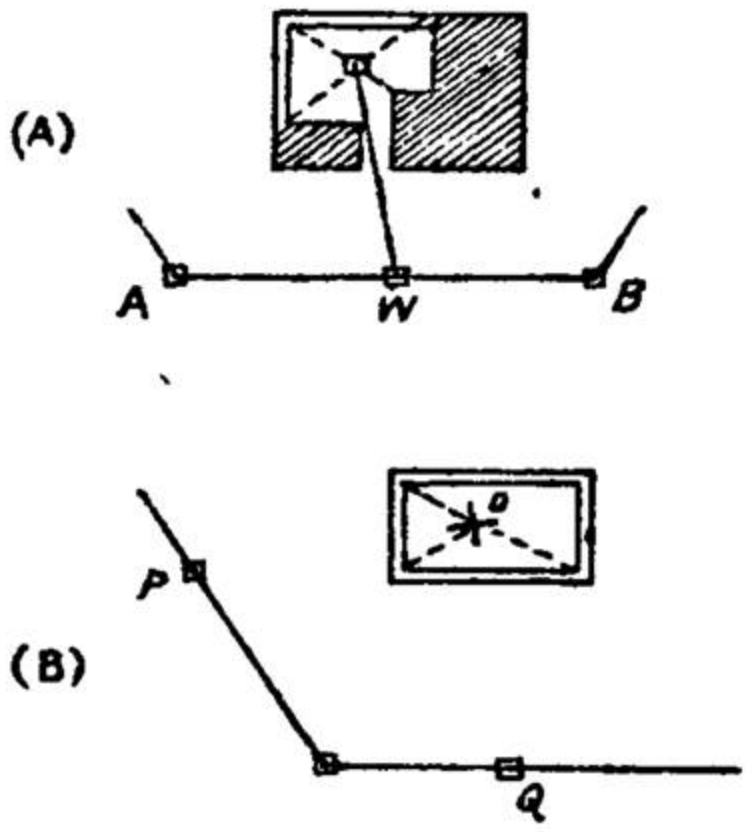


FIG. XII Page 21. Para 52.

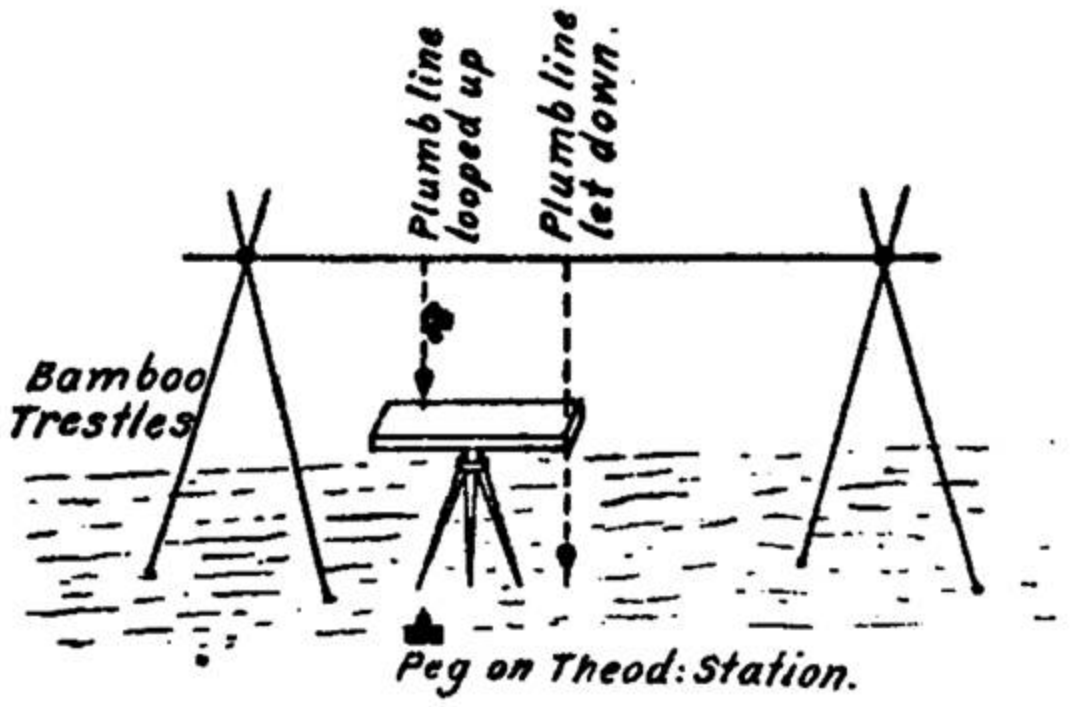


FIG. XIII. (1) Page 22, Para 53 (1).

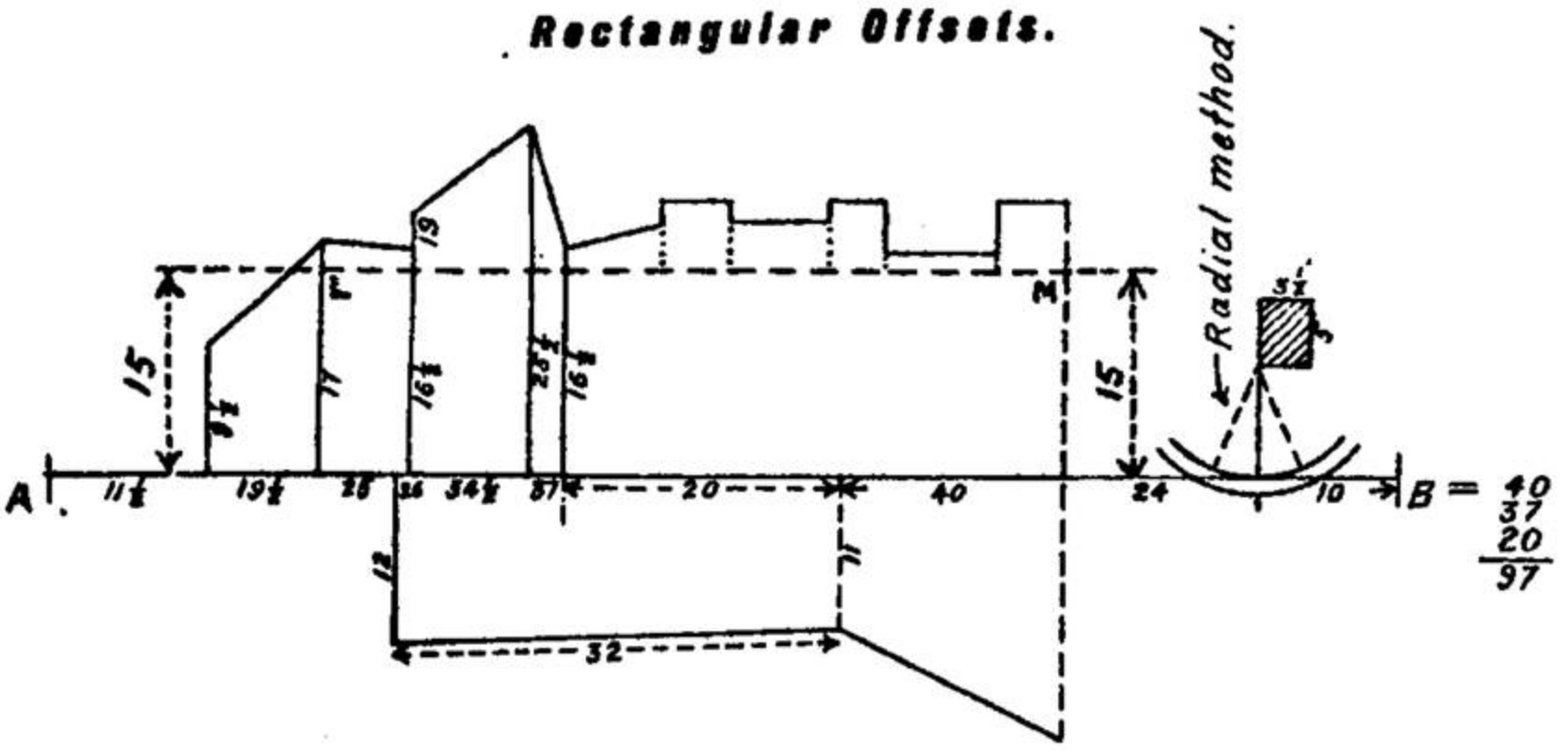
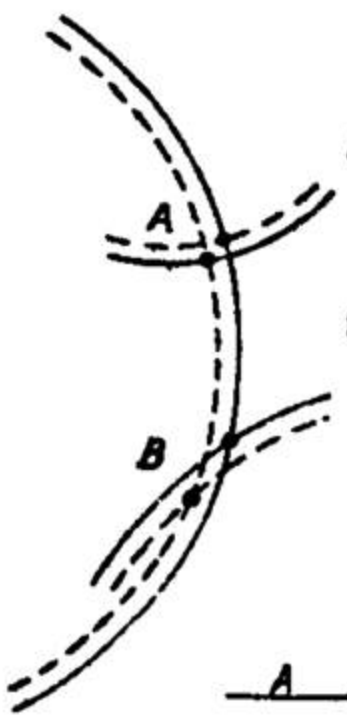


FIG. XIII. (2) Page 22, Para 53 (2).



A. In almost rectangular intersection a small error in either circle makes an error of the same magnitude in the position of the point.

B. In oblique intersection a small error makes a much greater error in the position of the point.

Arc Intersections.

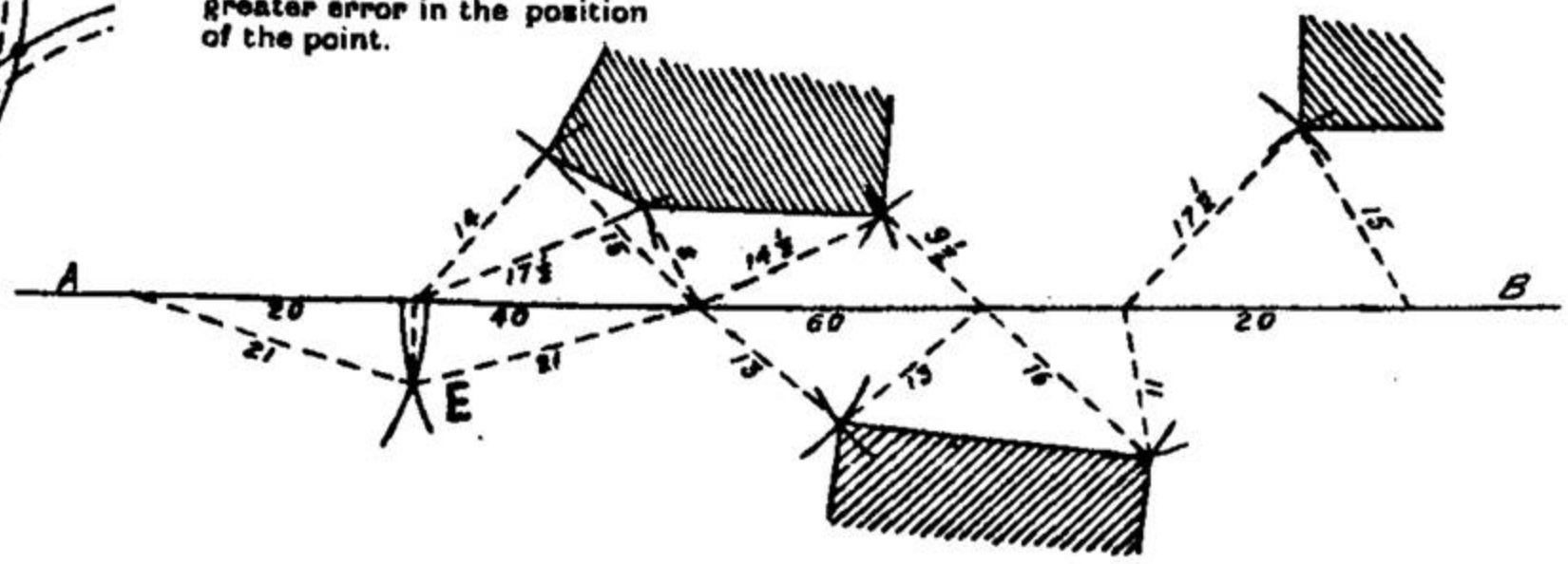


FIG. XIII(3) Page 22, Para 53 (3) & (4).

Plane Table intersection and directly measured rays (— · · —)

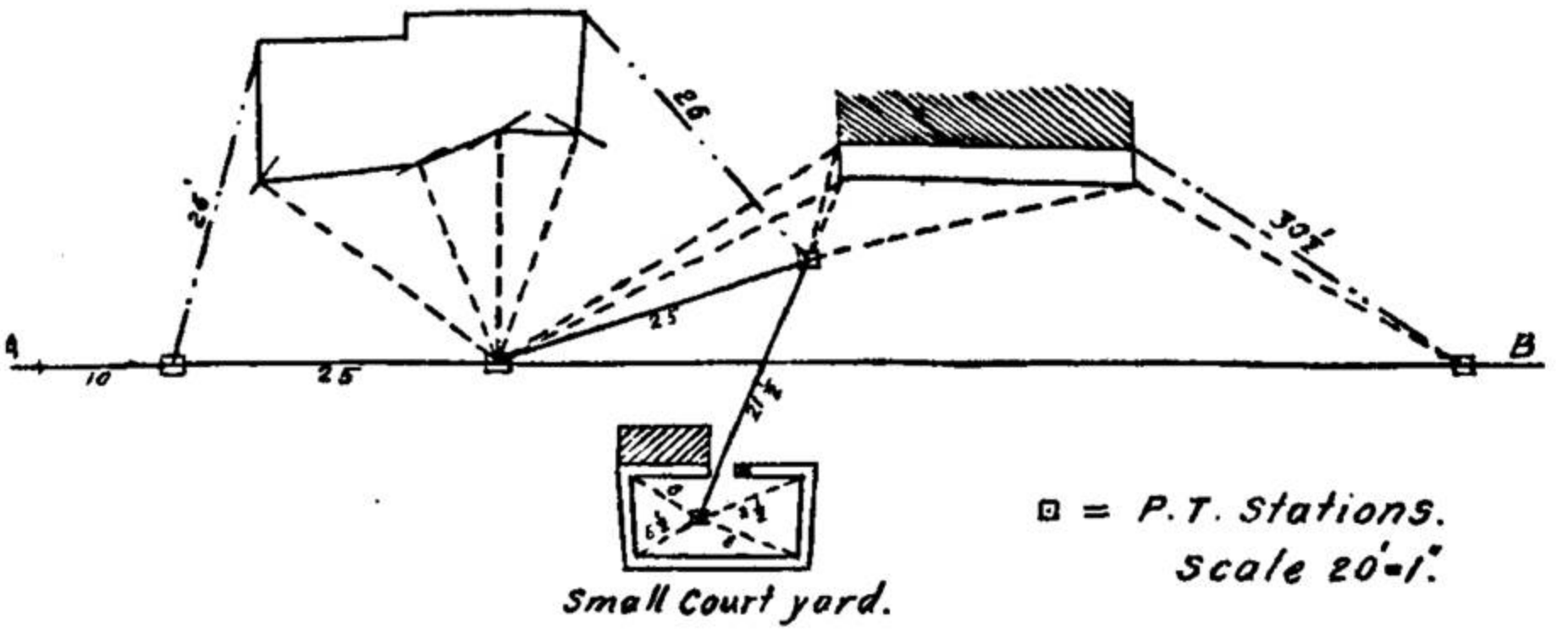
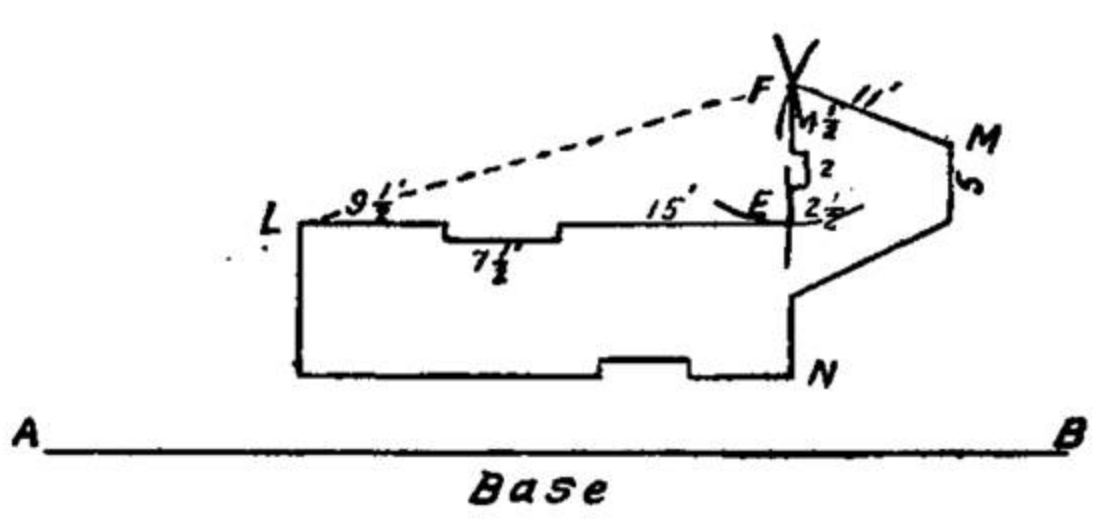


FIG. XIV. Page 23, Para 54.

'Blind' Points.



F is fixed by arc intersections from M and L. Then E from F and L; and the details along L E and E F are measured and plotted.

FIG. XV. Page 23, Para 55

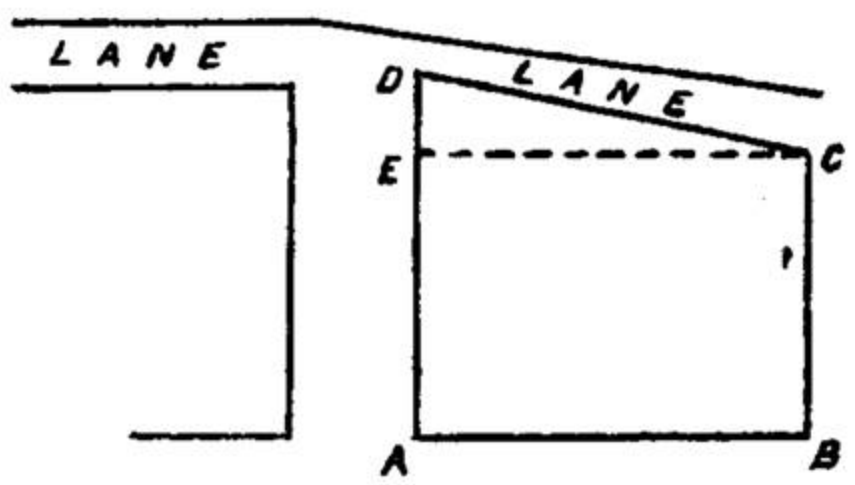


FIG. XVI.

Page 23. Para 56.

Point A should be taken as the property boundary.

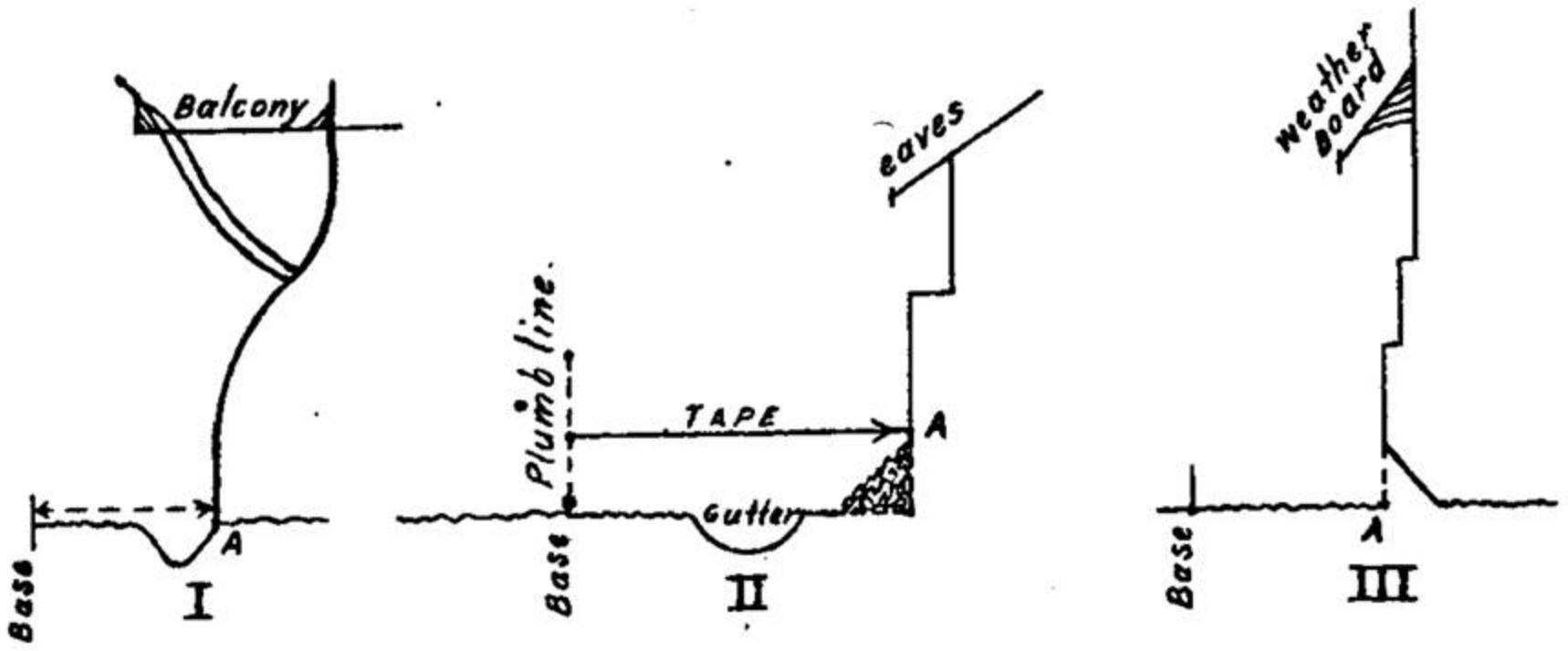
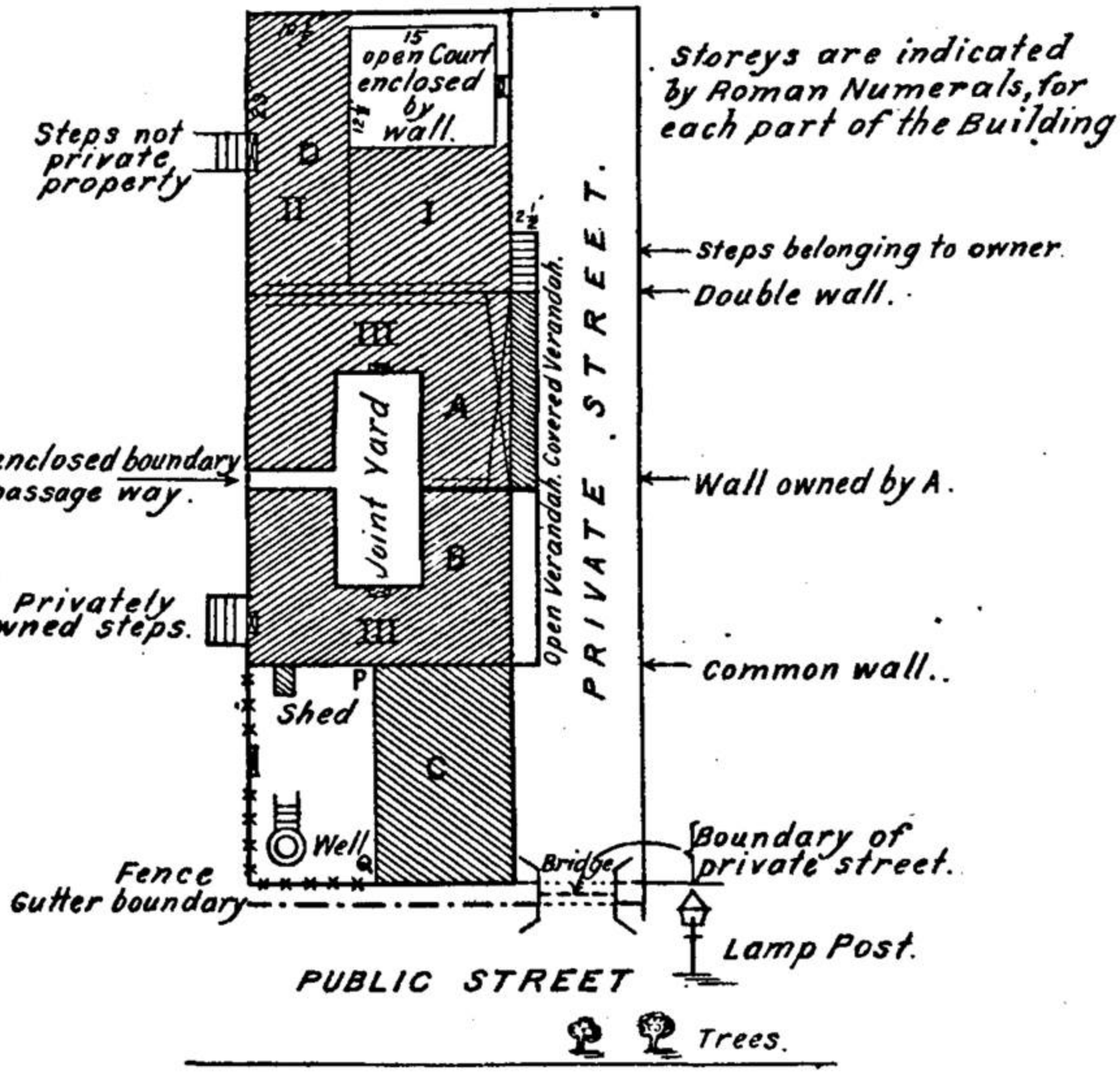


FIG. XVII.

Pages 25 & 41. Paras 58, 59 & 97.



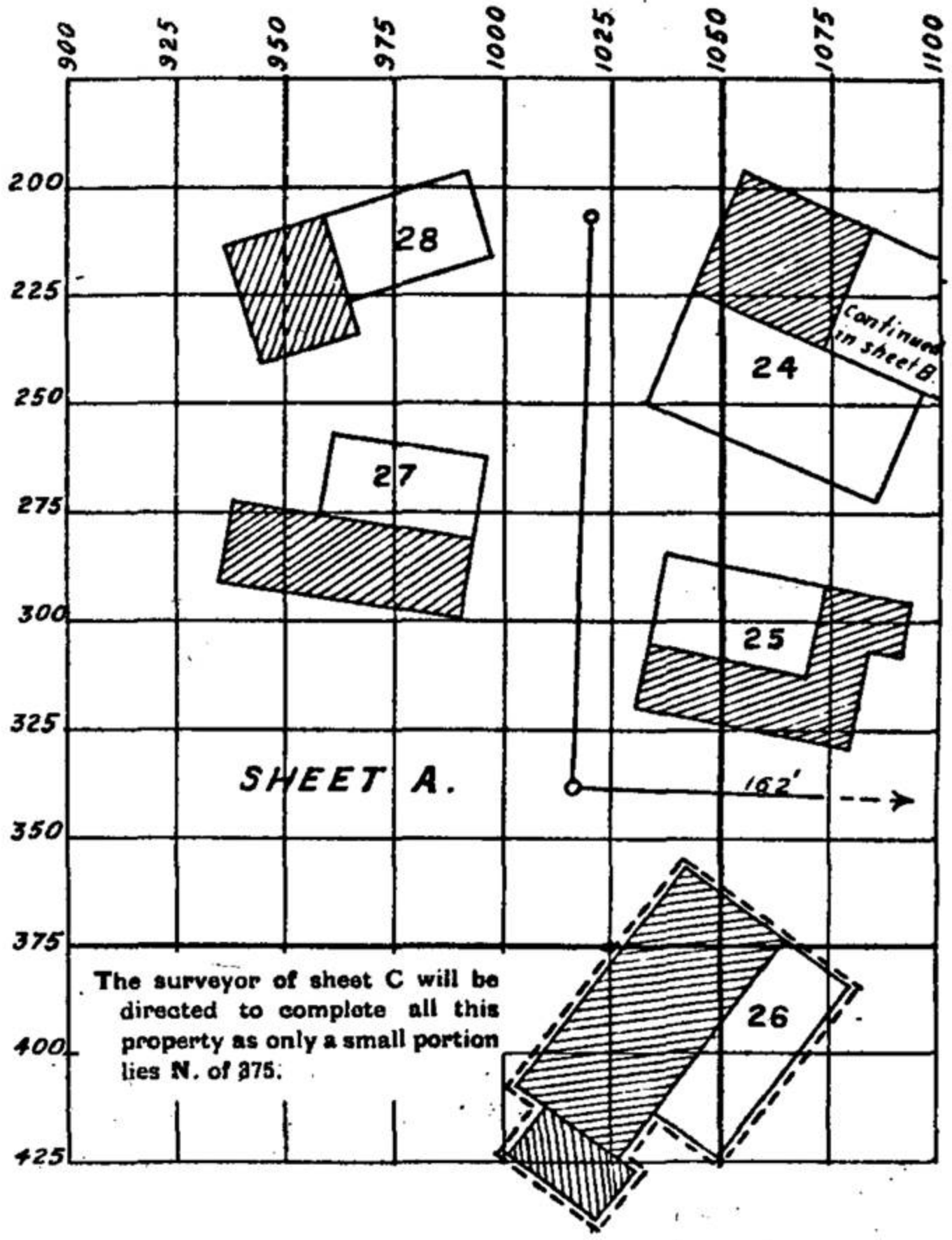
D is a house partly of one floor, partly of two.

C is a house with one (ground) floor only.

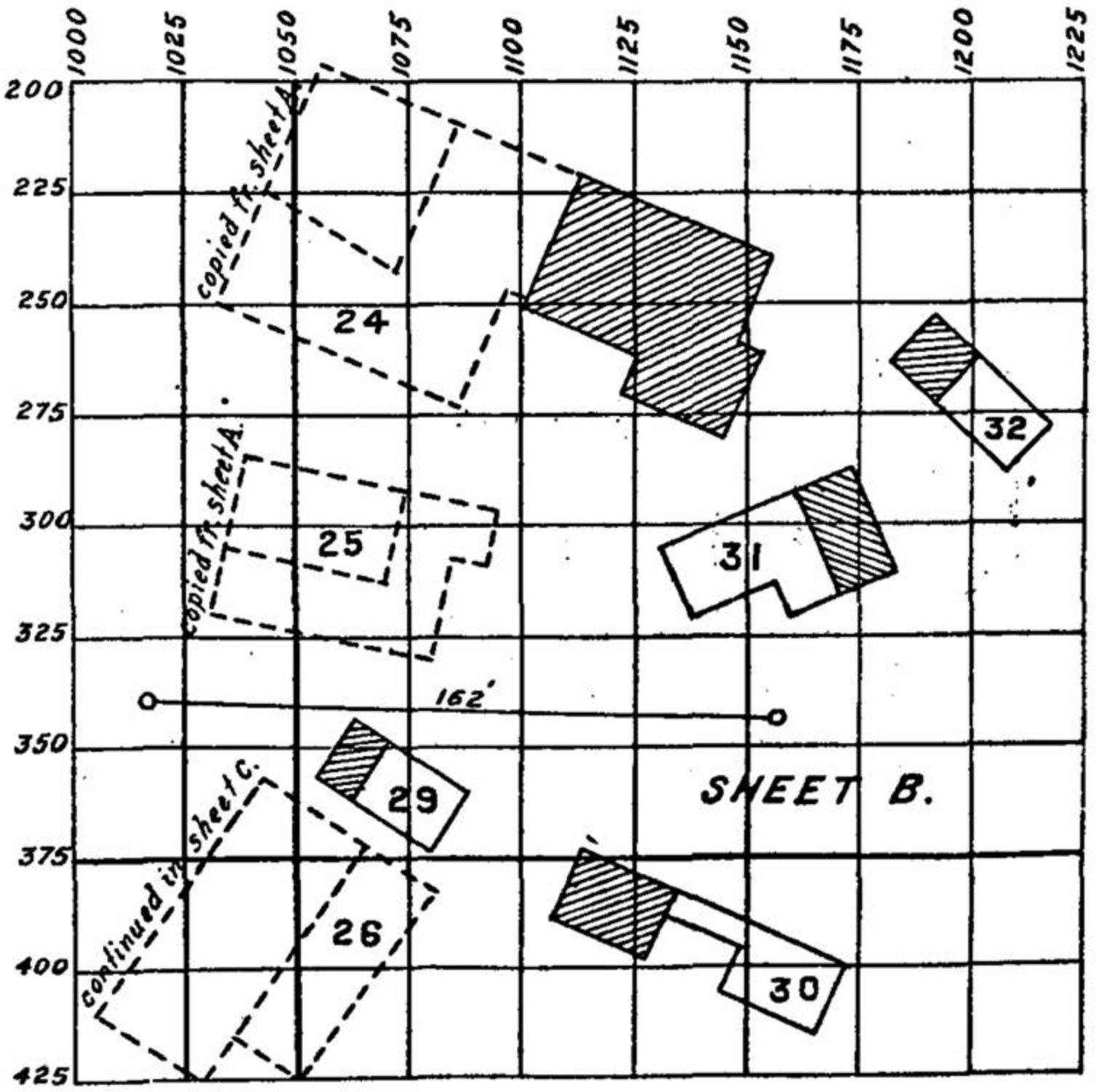
N.B.—The internal boundaries between built and unbuilt portions are light lines.

The external boundaries of properties are heavy lines.

FIG. XVIII. Page 28, Para 67.



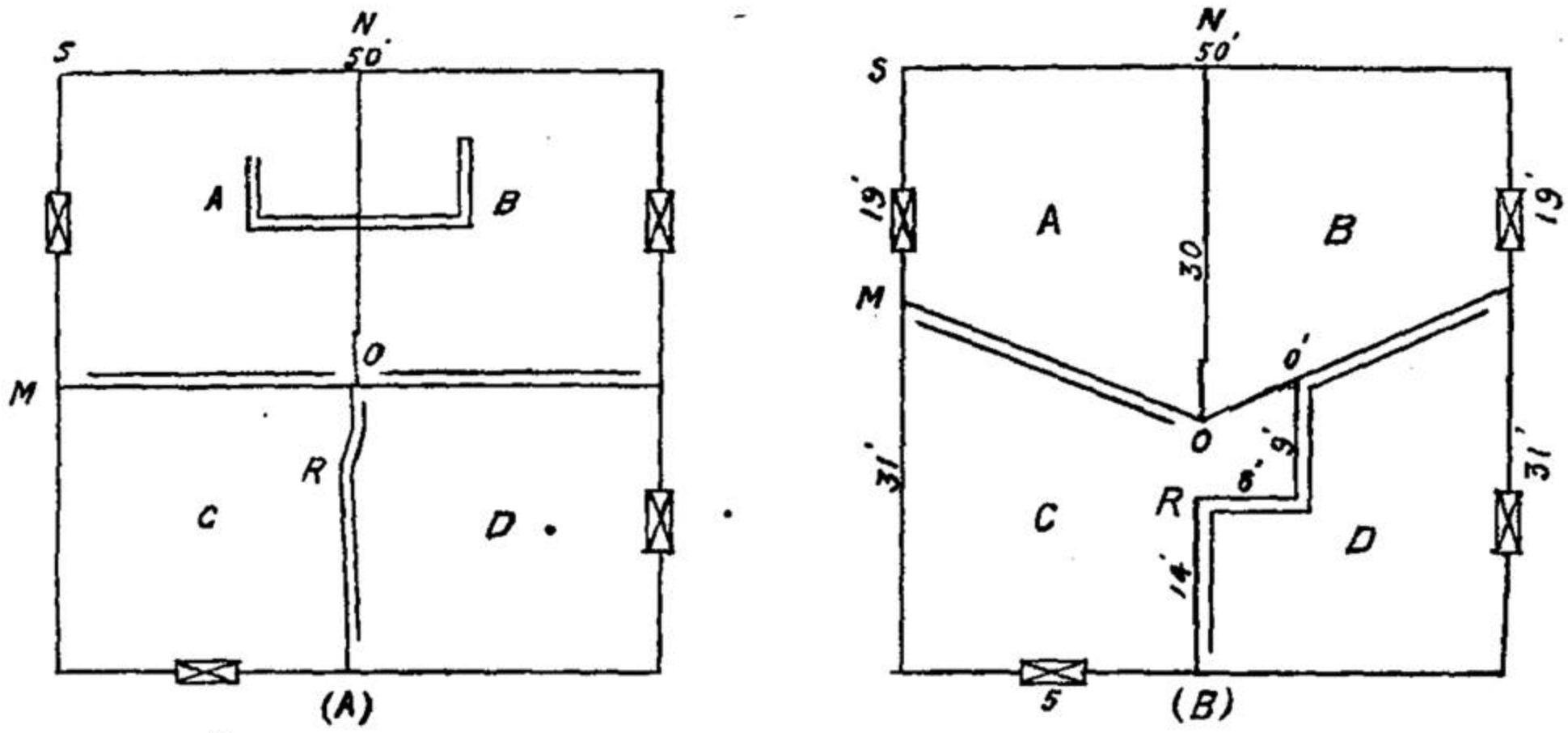
The surveyor of sheet A will map all properties which begin West of 1050 and North of 375. But if they run beyond 1100/425 he will leave ***the rest*** to be done by the Surveyors of sheets B and C. But he can leave all No. 28 to sheet C by special arrangement between the four Surveyors.



The Surveyor of sheet B will leave out the properties already mapped in sheet A and C. But ***in the Tracing*** the omitted details between 1050 and 1100, which are dotted, not lined, will be copied from the other sheets A and C. so that in joining for consolidated Map the junction can be made strictly along 1050/375 L L lines. Thus in the printed sheets very few properties will be broken.

FIG. XIX .

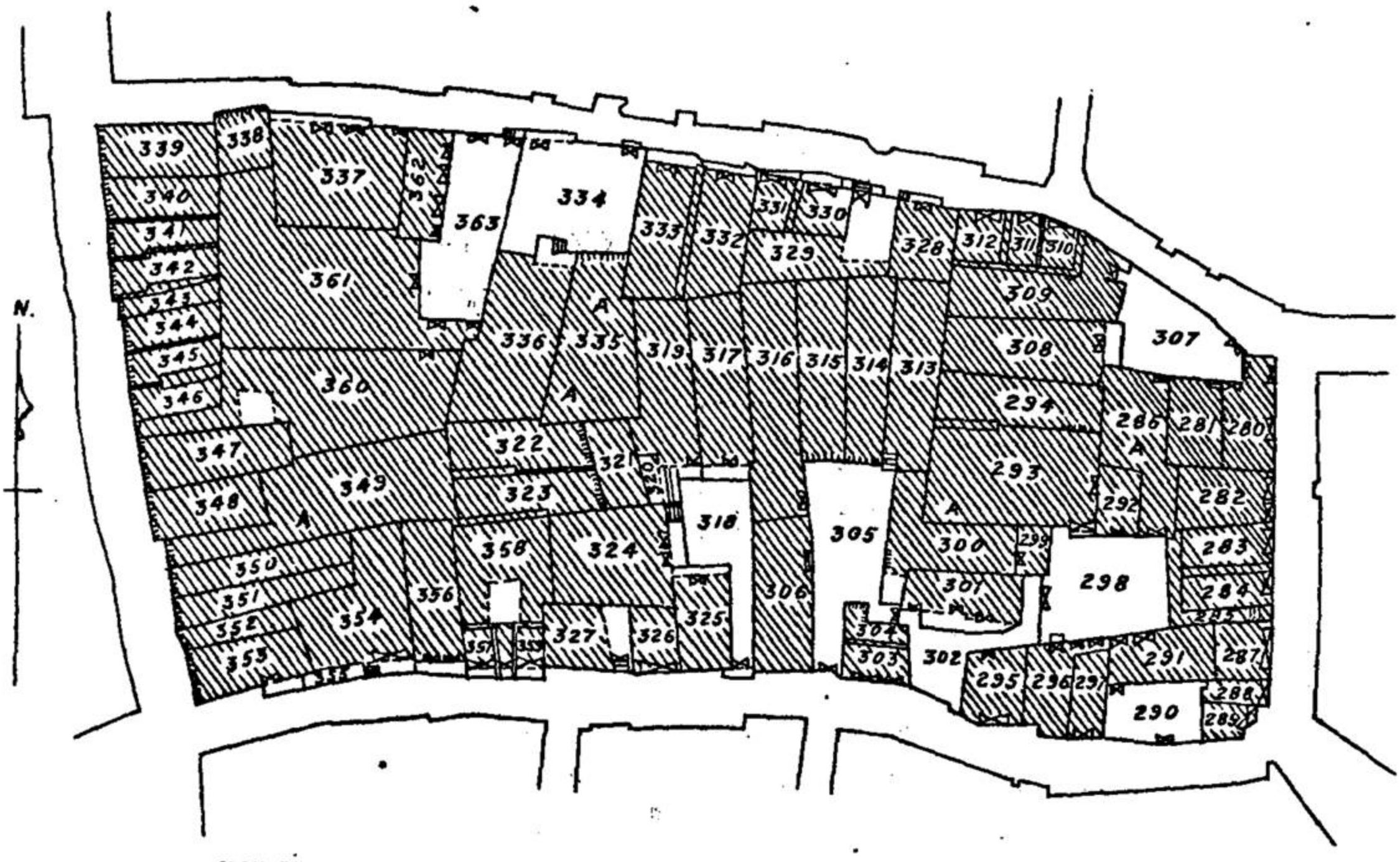
Page 31, Para 75



Internal Walls

FIG. XX (A)

Page 32, Para 76.



NOTE.

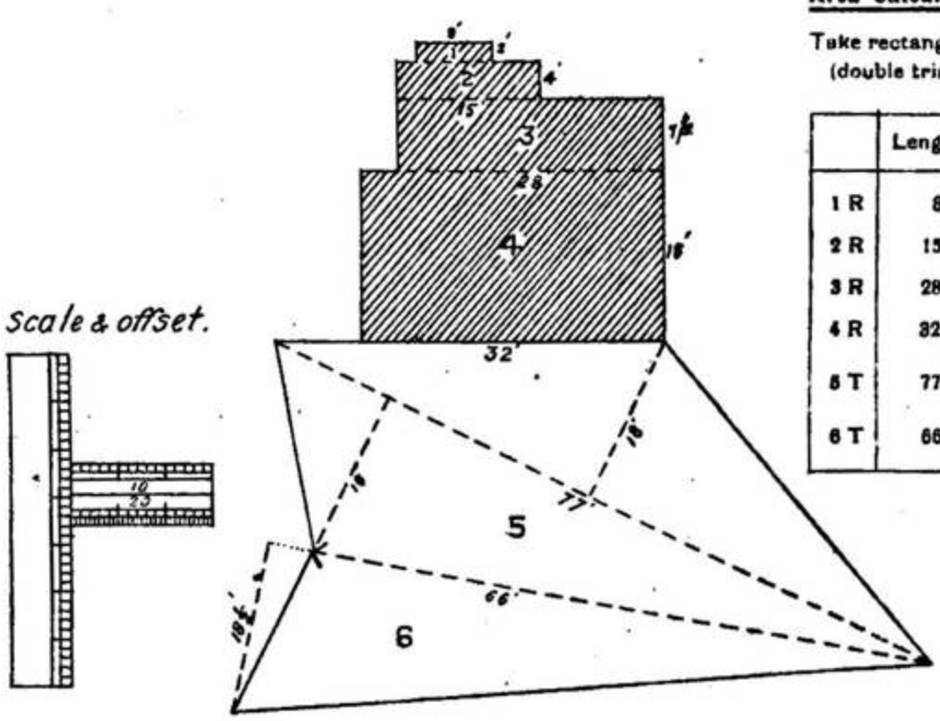
Symbol ⌇⌇⌇⌇ indicates passage through a covered verandah.

Portion of Shikarpur City (Sind).

Fig. XX (b) Page 32, Para 76.

Congestion in Shikarpur City.

FIG. XXI. Pages 33 & 82, Paras 78 & 20.



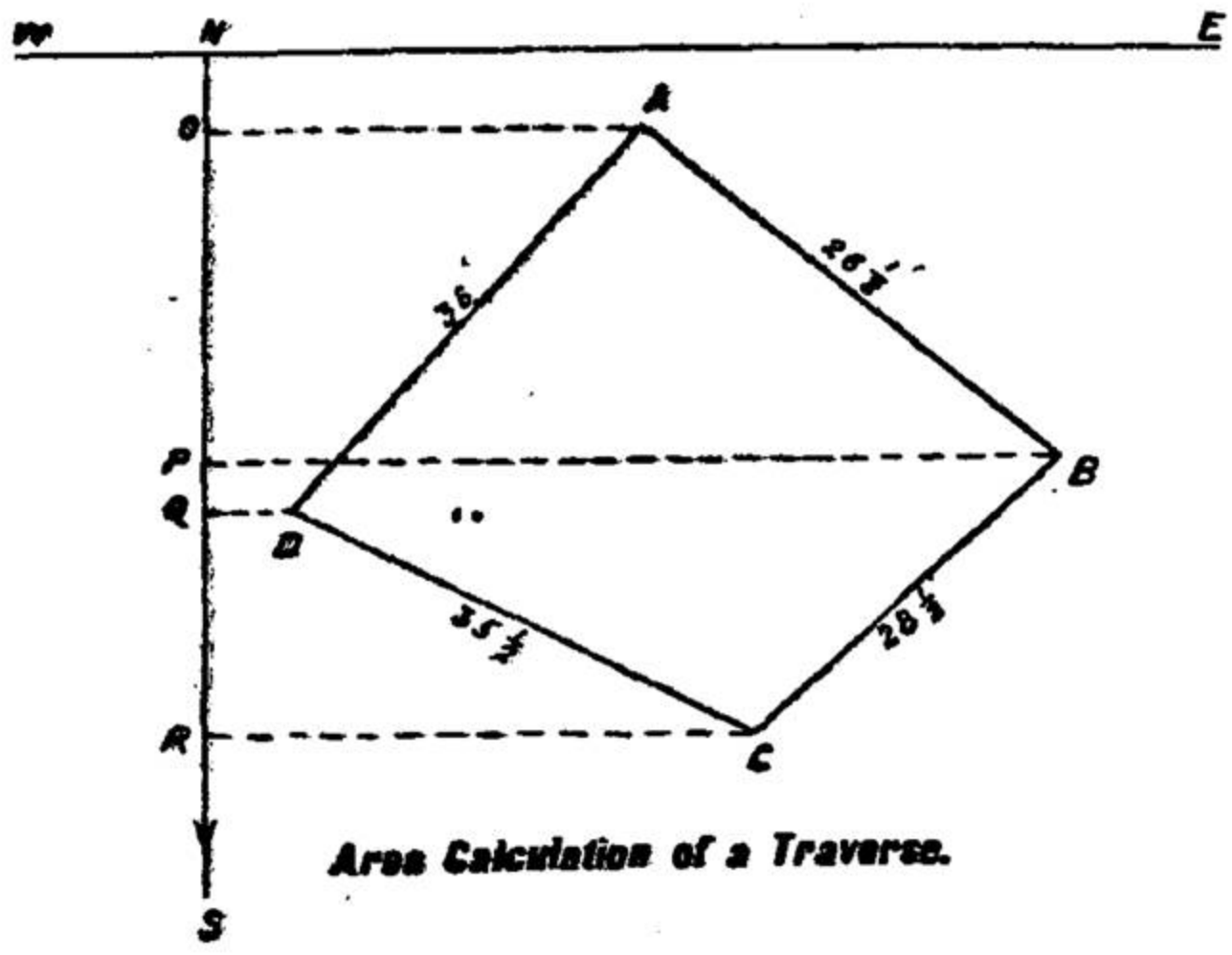
Area Calculation.

Take rectangles 1, 2, 3, 4, and then quadrilateral (double triangle) 5, and triangle 6, thus—

	Length.	Breadth.	Product.	Area.
1 R	8	2	16	16
2 R	15	4	60	60
3 R	28	7½	210	210
4 R	32	18	576	576
5 T	77	18 / 18 } 36	2772	1386
6 T	66	18½	1221	610½

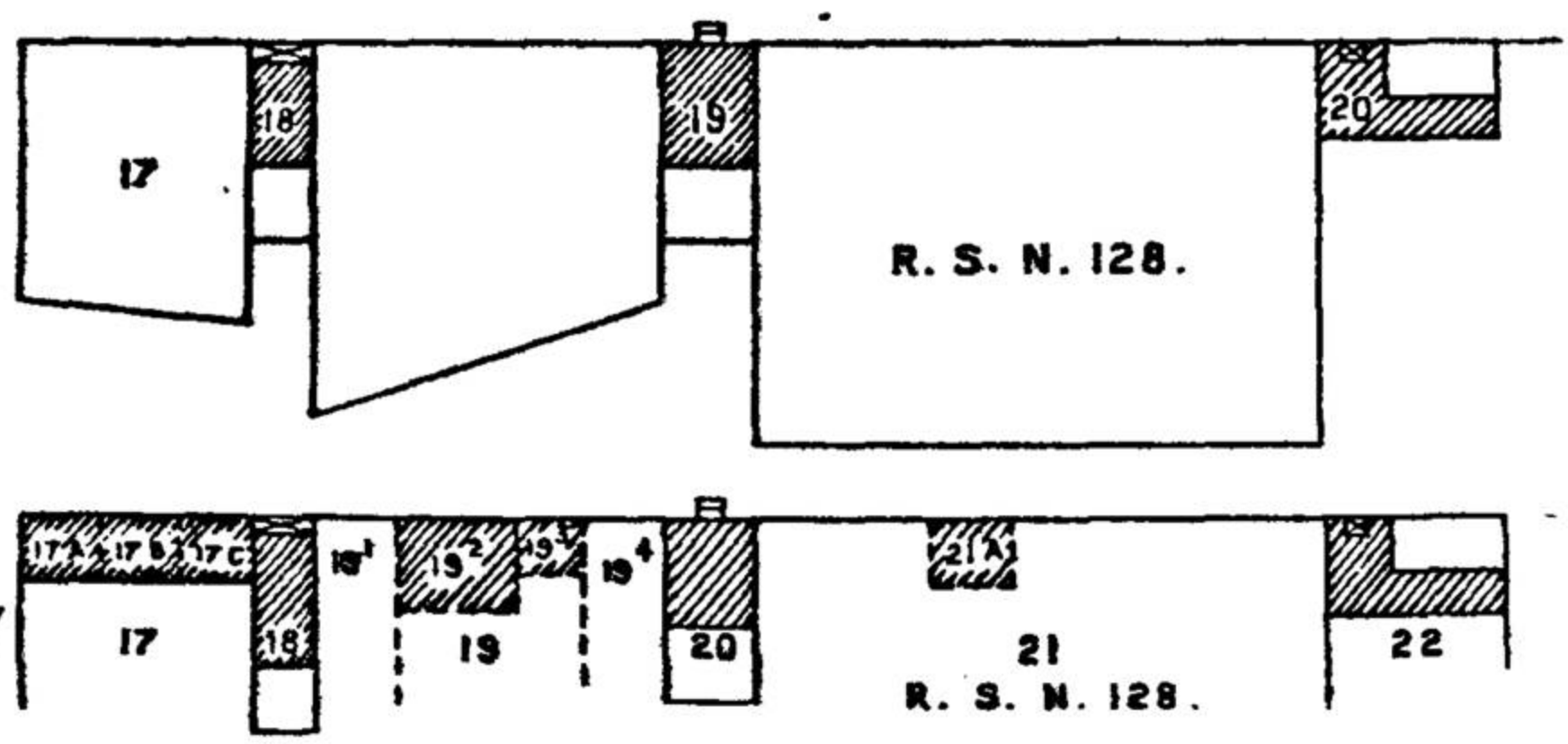
Total area. 2858½

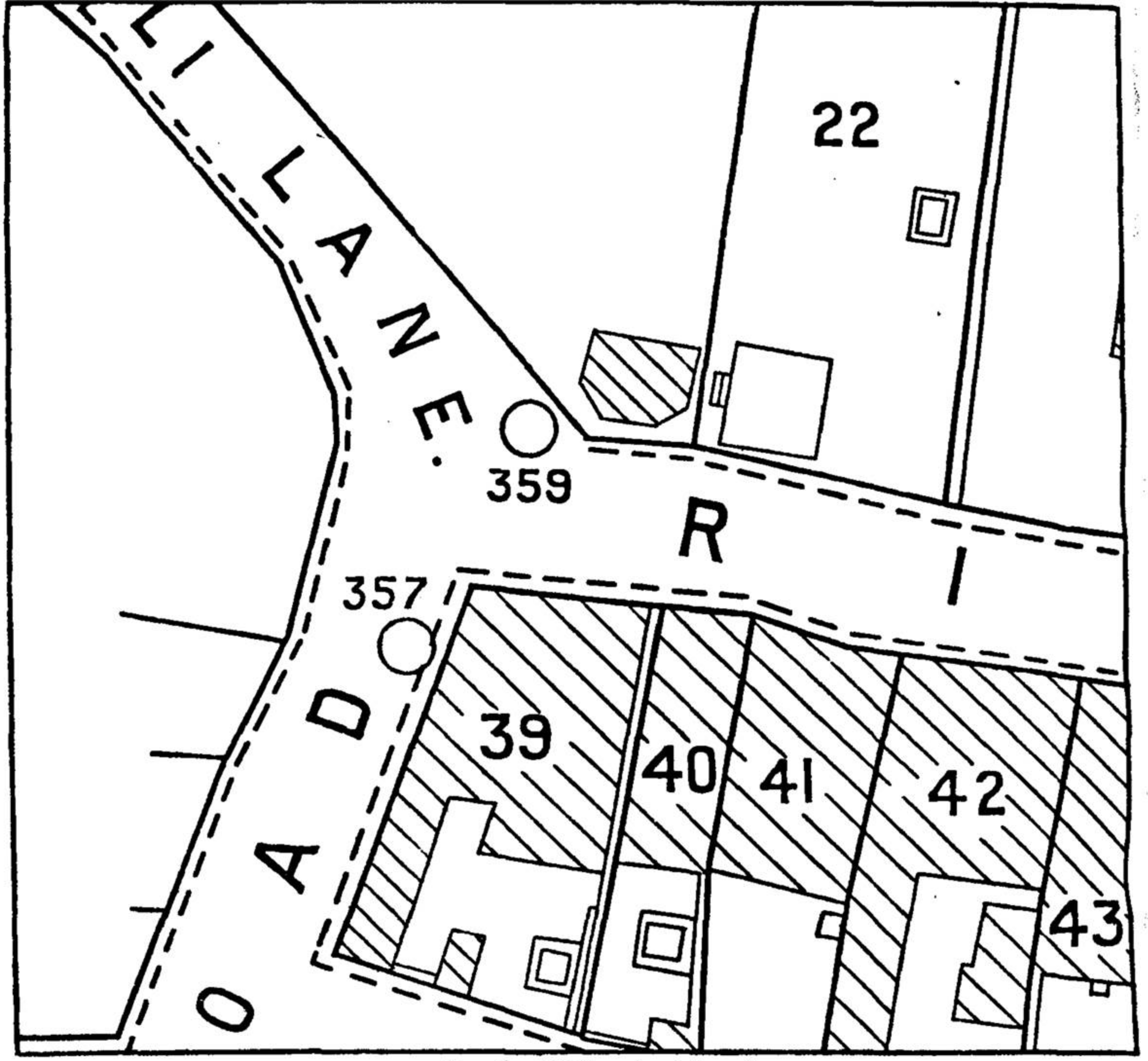
FIG. XXII. Page 33, Para 80.



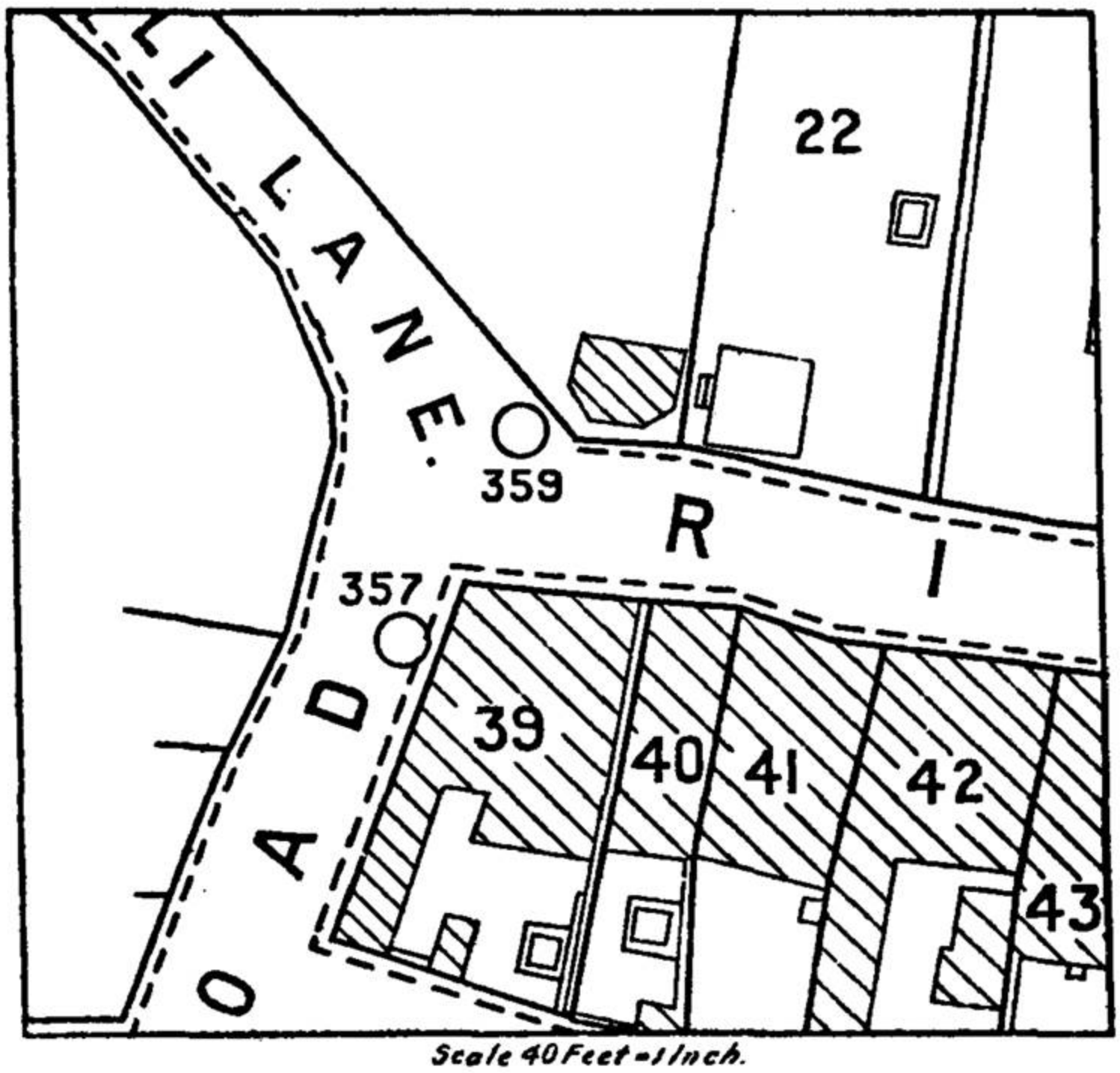
Area Calculation of a Traverse.

FIG. XXIII. Pages 35 & 69, Paras 85 & 158.





Scale 25 Feet = 1 Inch.



Scale 40 Feet = 1 Inch.

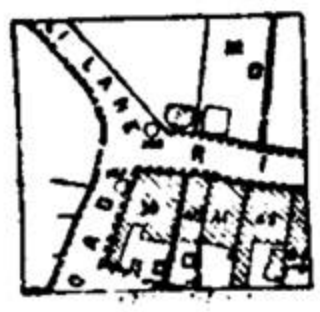


FIG. XXIV Page 54, Para 13

Relative size of figures, letters and lines i
uniform reduction.

FIG. XXIV (A)

Page 55, Para 133.

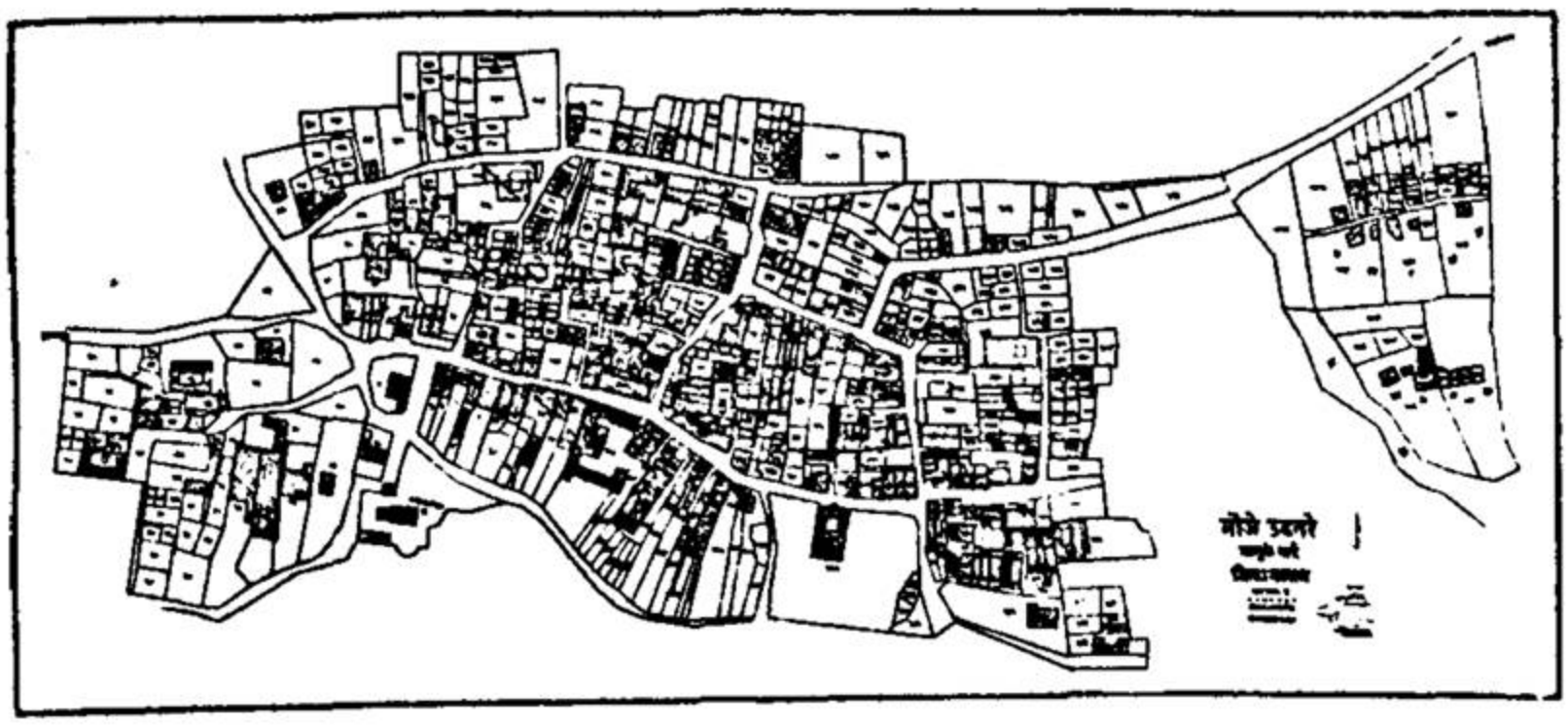


FIG. XXV

Pages 72 & 73, Paras 172 & 174

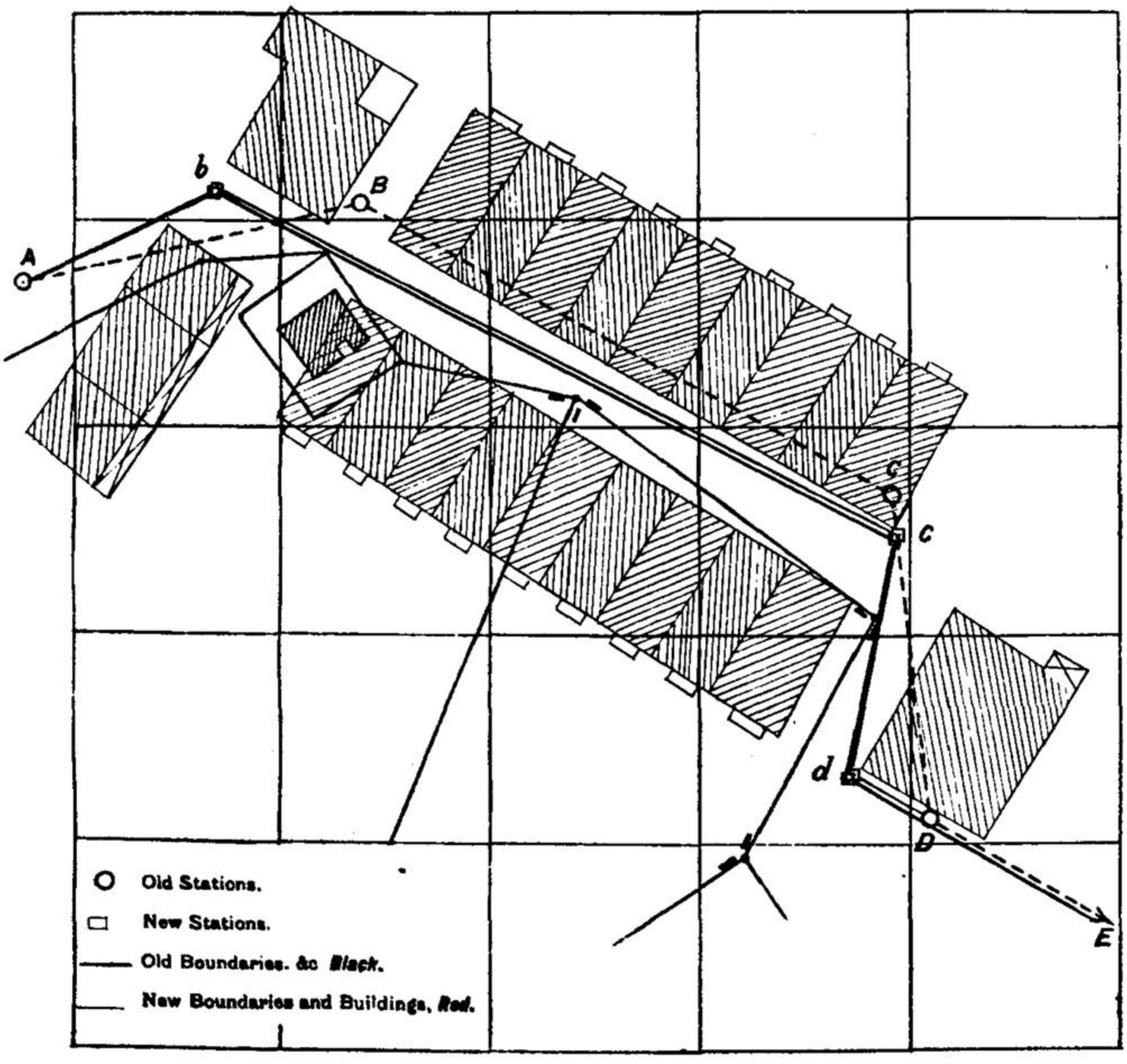
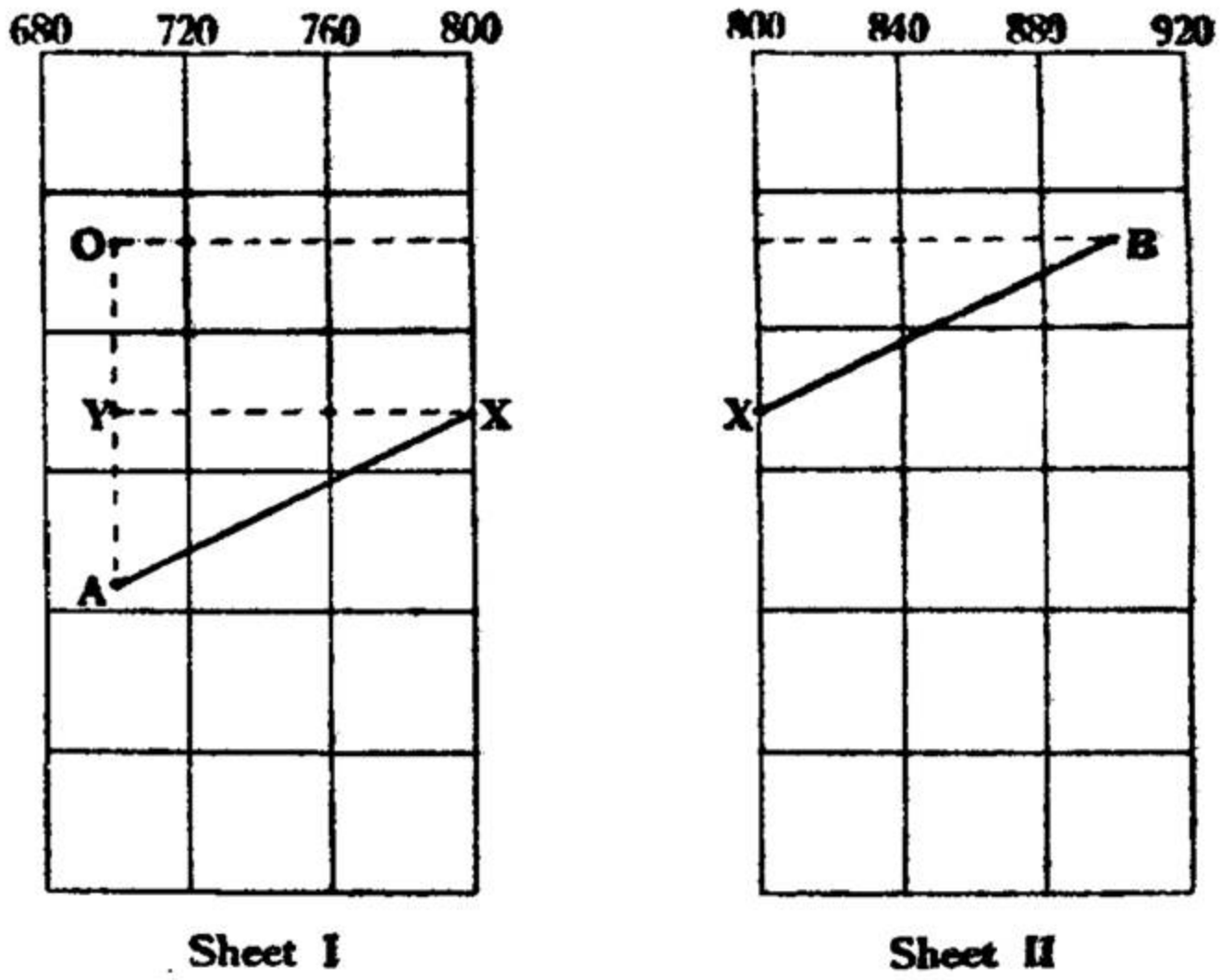


FIG. XX VI.

Page 19, Para 49.

Traverse legs intersecting sheet boundaries.



Sheet I

Sheet II

Fig: XXVII. (see para 51, page 20.)

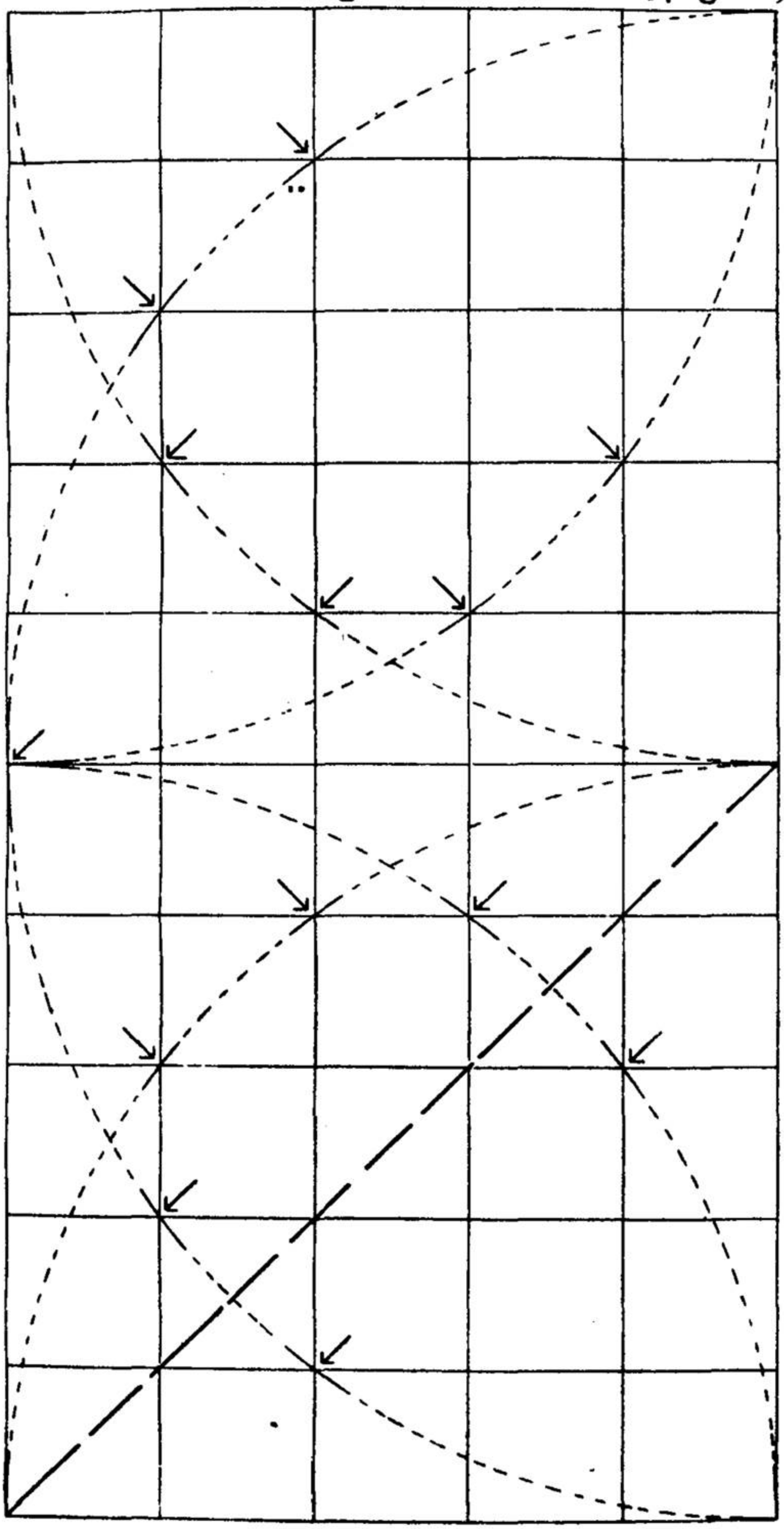
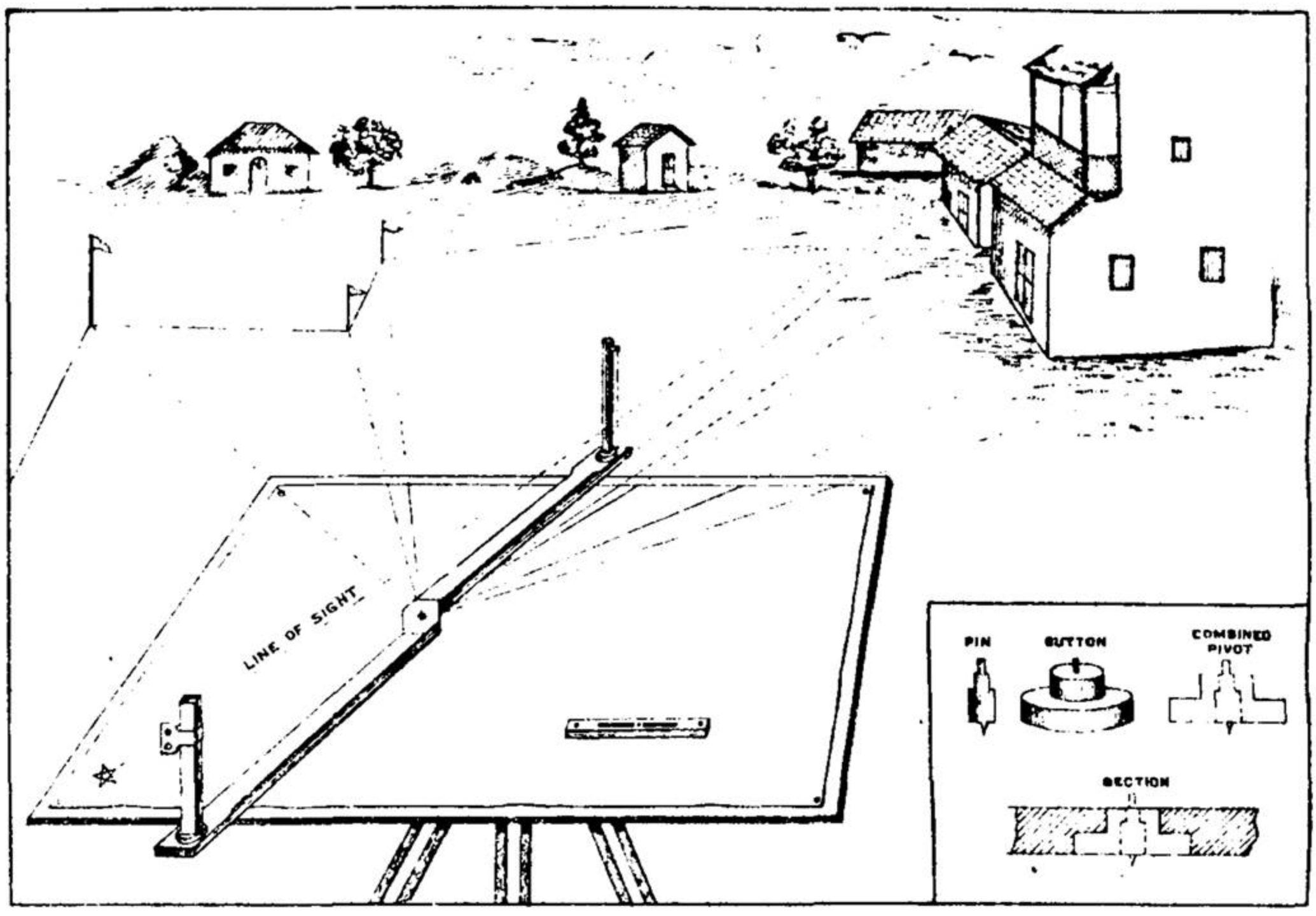
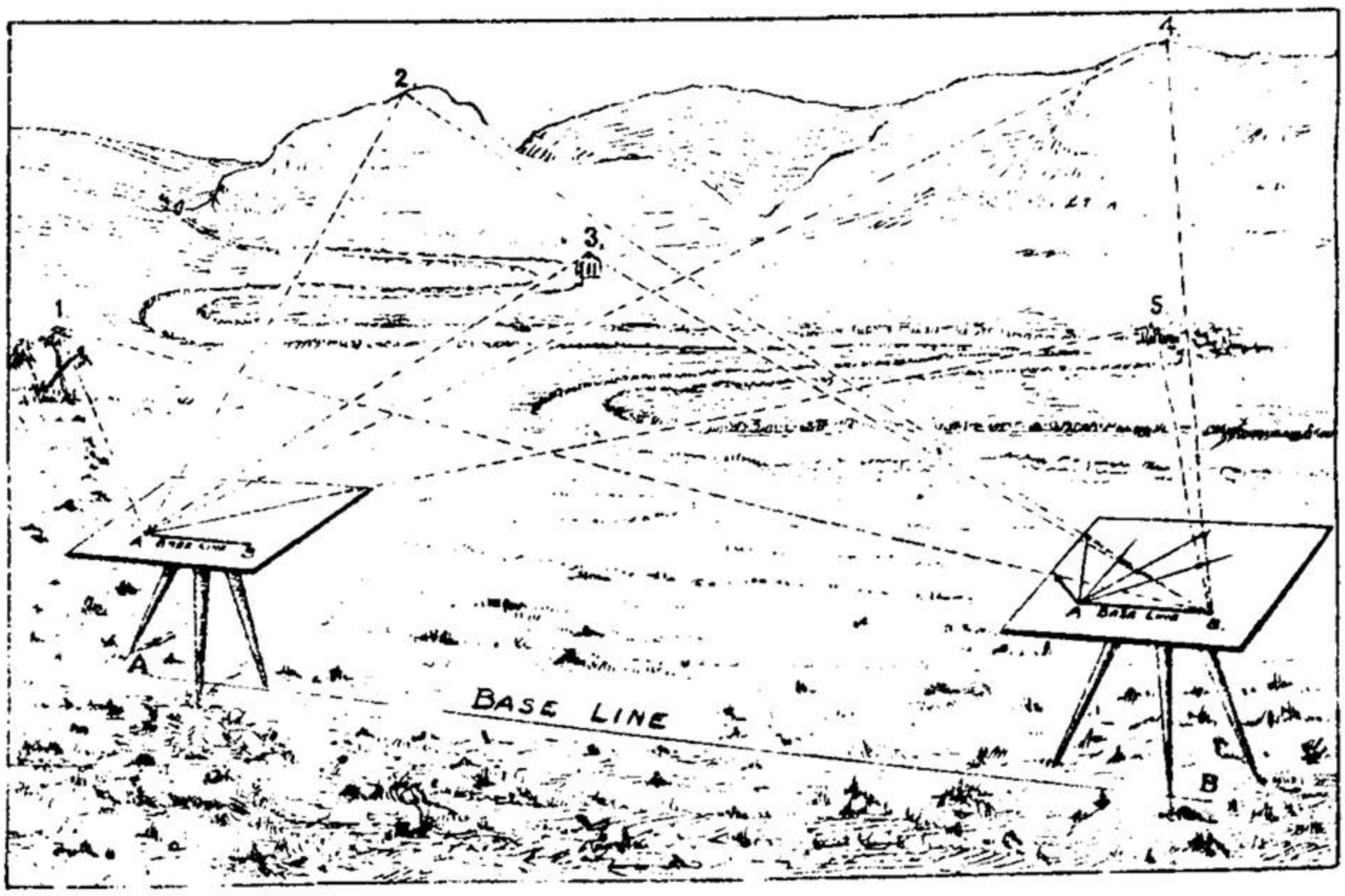


FIG. XXVIII. Pages 75, 76 & 77, Paras 1, 5 & 8.



General view of implements.

FIG. XXIX. Page 75, Para 1.



General view of operations.

FIG. XXX. Page 77, Para 6.

Selection of Bases.

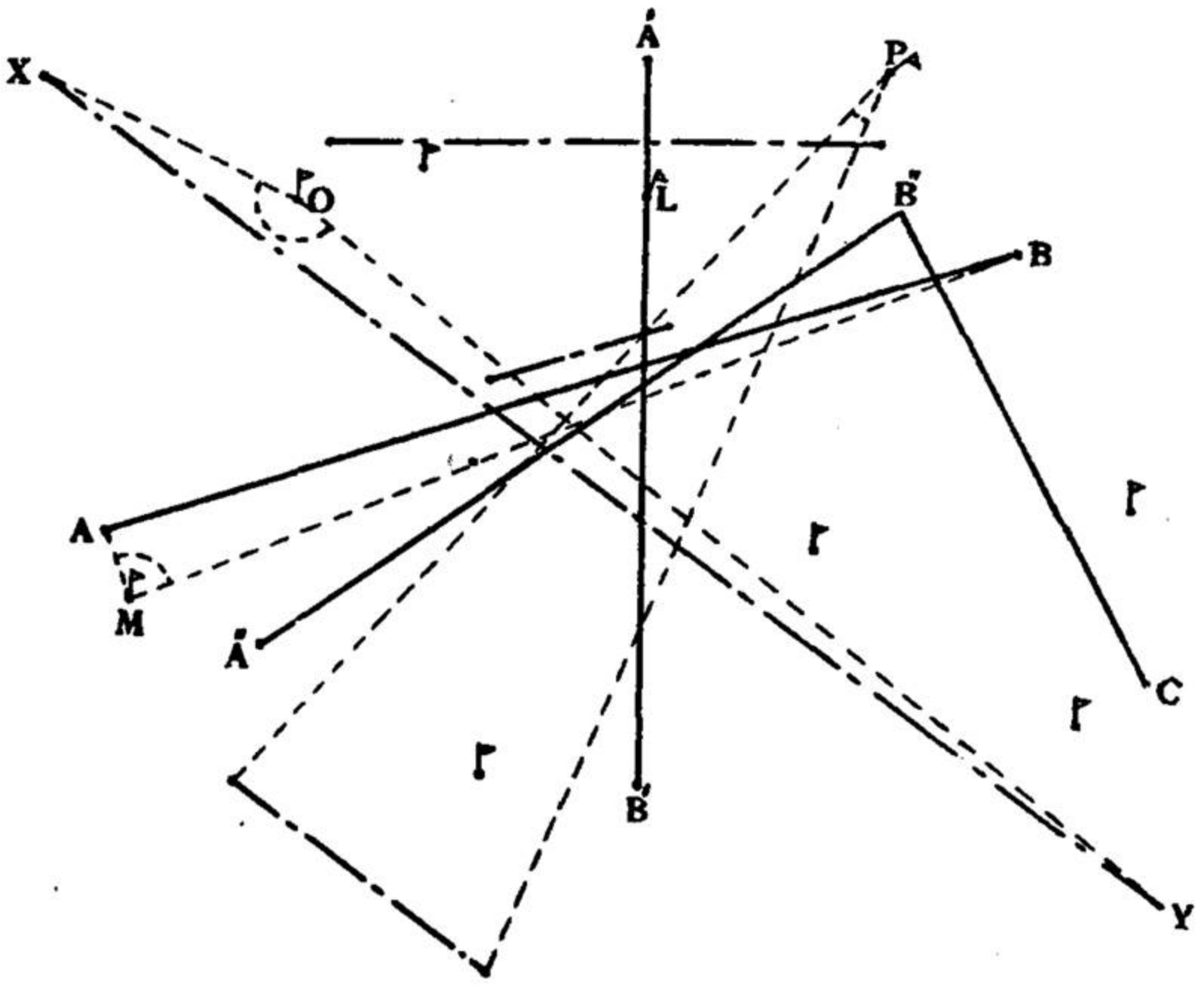


FIG. XXXI. Page 78, Para 8 (3).

Tree trunk of Boundary Mark.

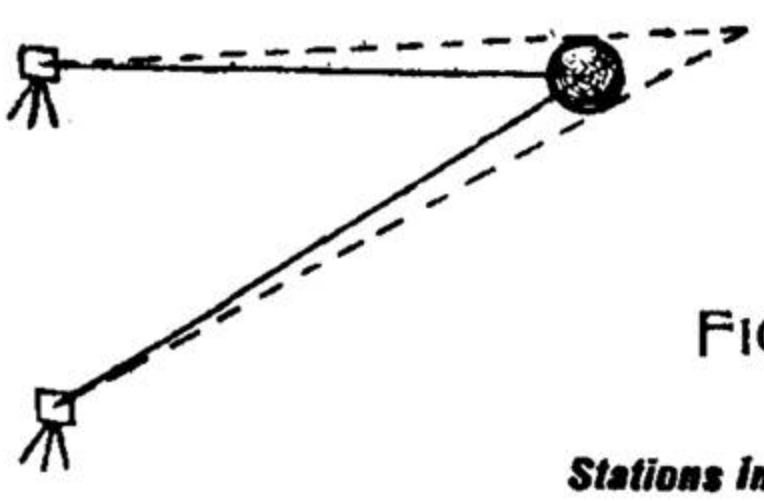


FIG. XXXII. Page 77, Para 6.

Stations in a Straight Line.

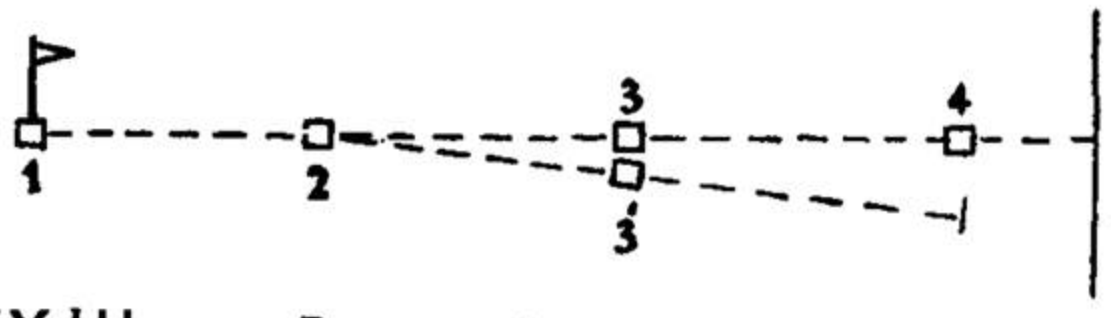


FIG. XXXIII. Pages 77 & 79, Paras 7 & 9 (6).

Stations in Knights Moves.

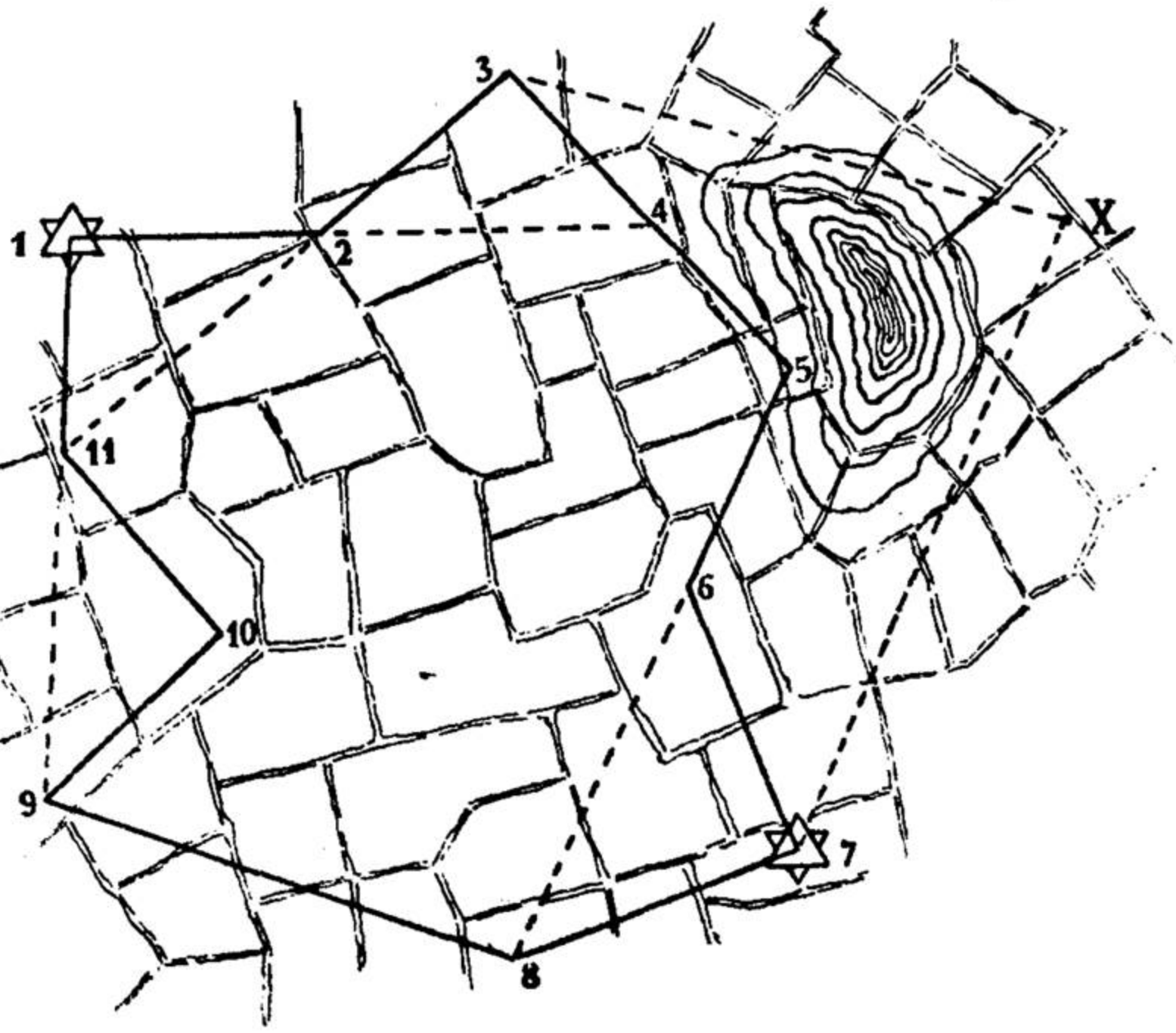


FIG. XXXIV. Page 78, Para 9 (1).

New Station by Intersection.

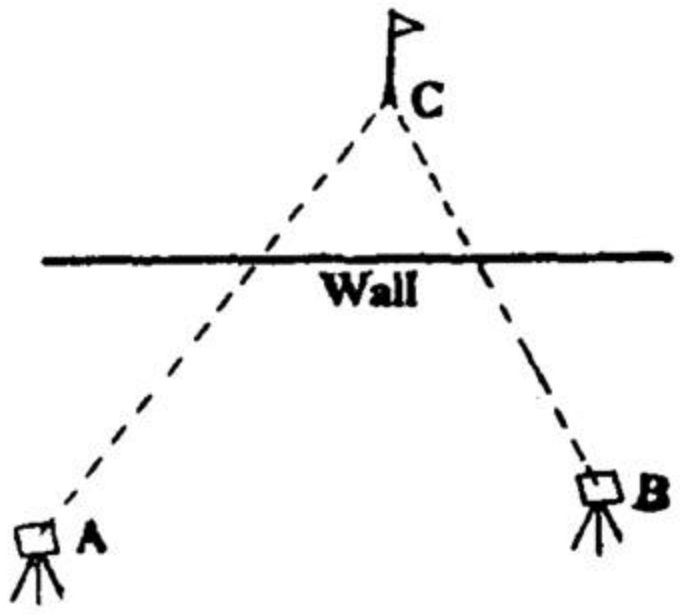


FIG. XXXV. Page 78, Para 9 (3).

Invisible Marks.

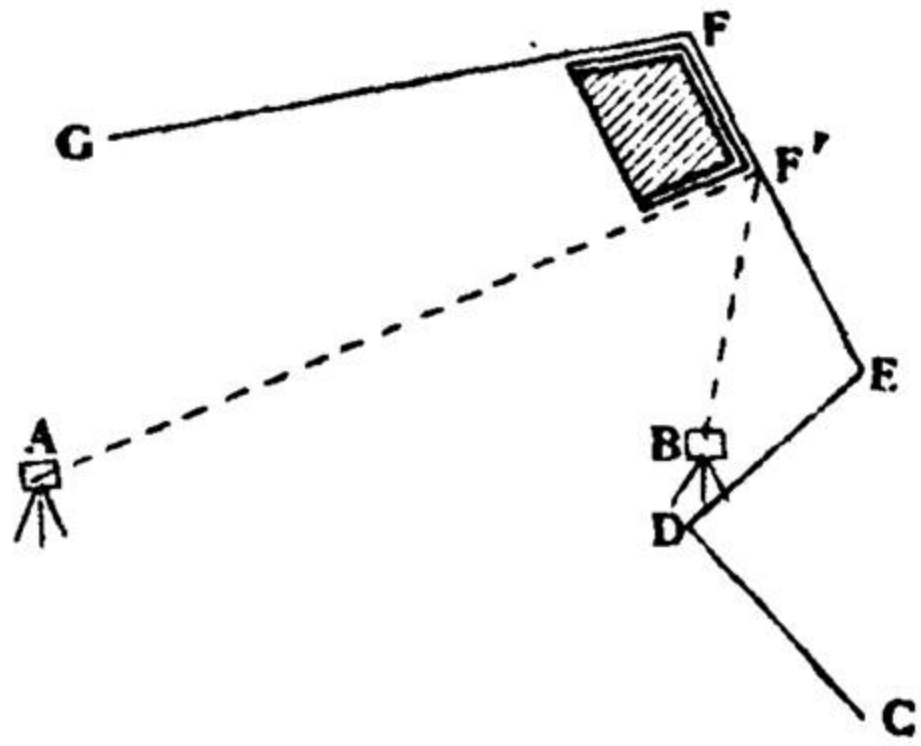


FIG. XXXVI. Page 78, Para 9 (2) & (4).

Single Rays and Single Intersections.

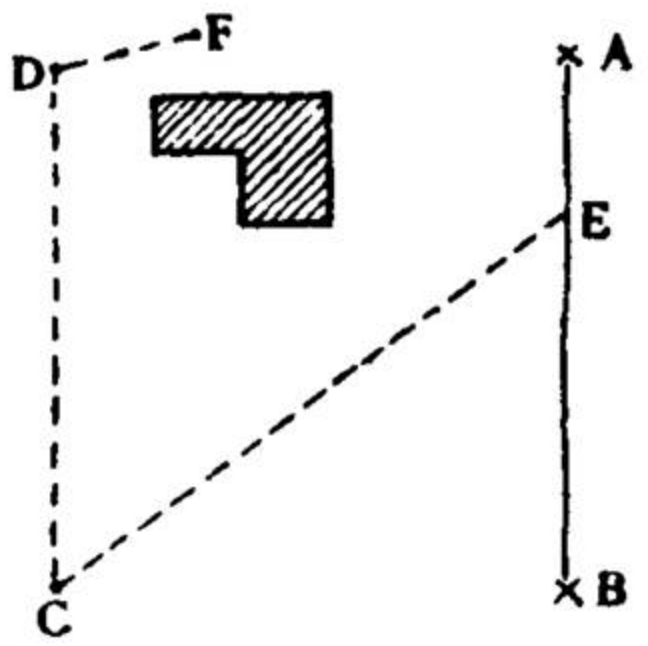


FIG. XXXVII. Page 79, Para 9 (5).

Rays on Steep Slopes.

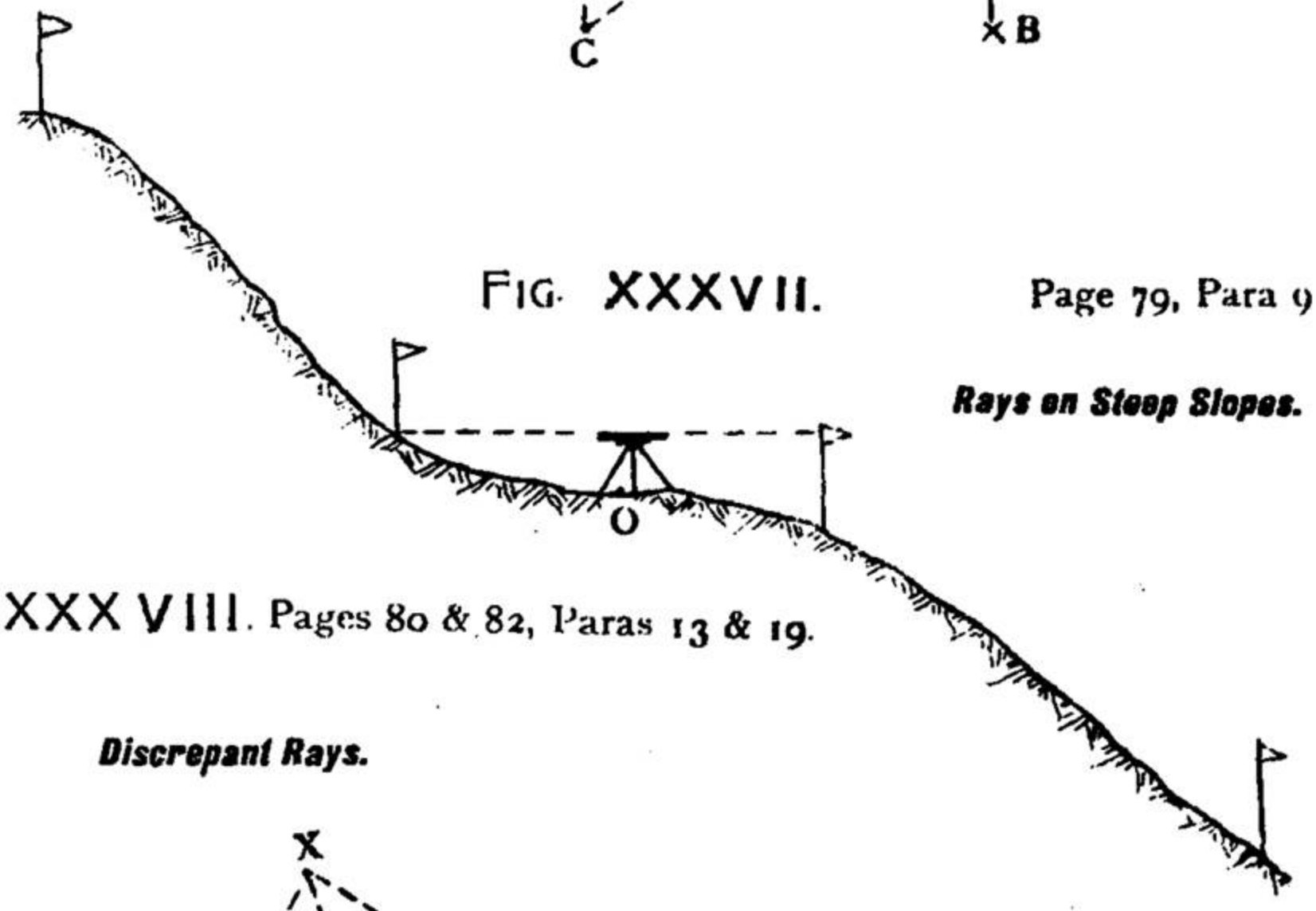
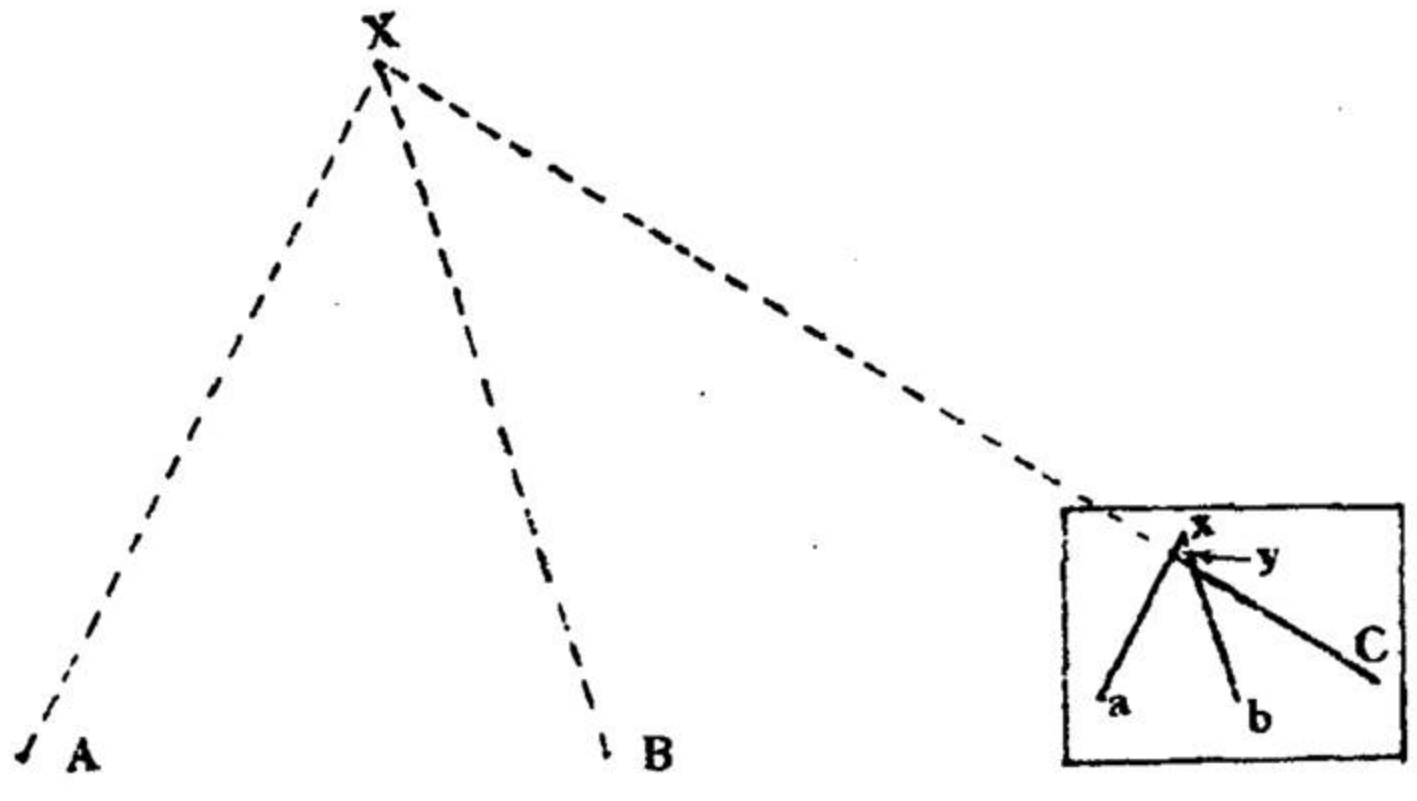


FIG. XXXVIII. Pages 80 & 82, Paras 13 & 19.

Discrepant Rays.



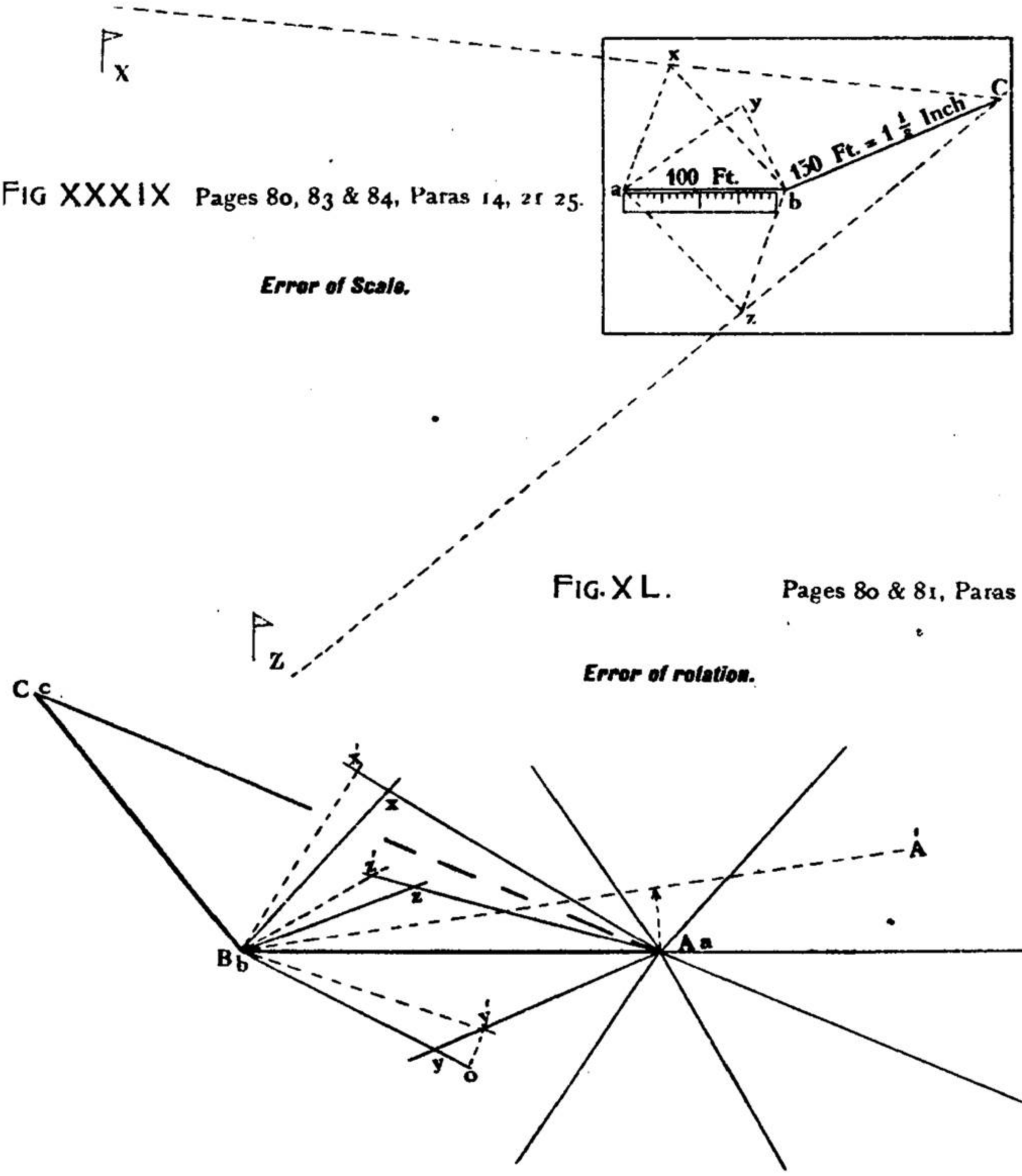


FIG XXXIX Pages 80, 83 & 84, Paras 14, 21 25.

Error of Scale.

FIG. XL. Pages 80 & 81, Paras 15 & 16

Error of rotation.

FIG. XLI. Page 82, Para 18.

Error of Centering.

FIG. XLII. Pages 82 & 84, Paras 20 & 25.

Three Points Determination.

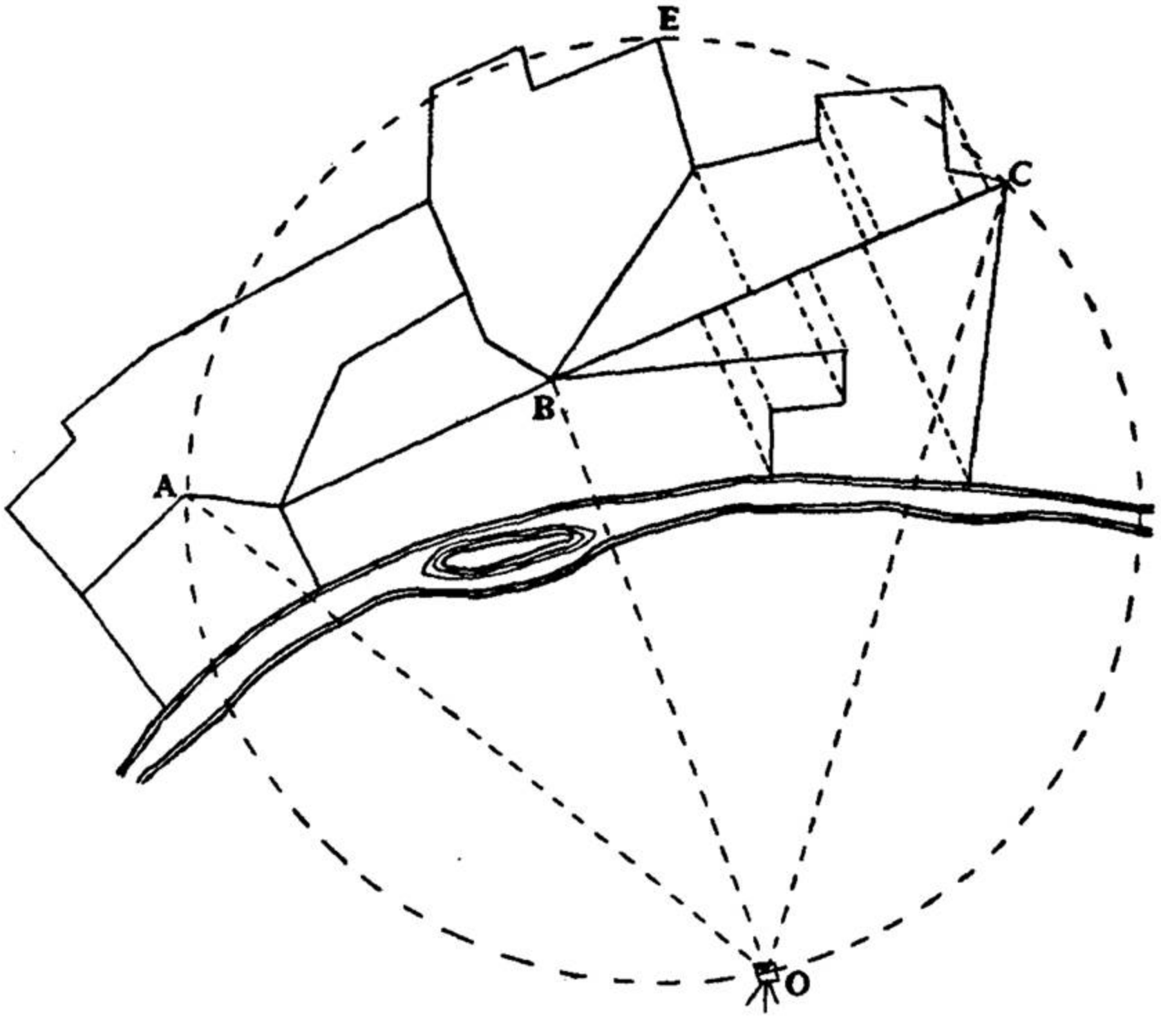


FIG. XLIII. Page 84, Para 25.

Triangle of Error.

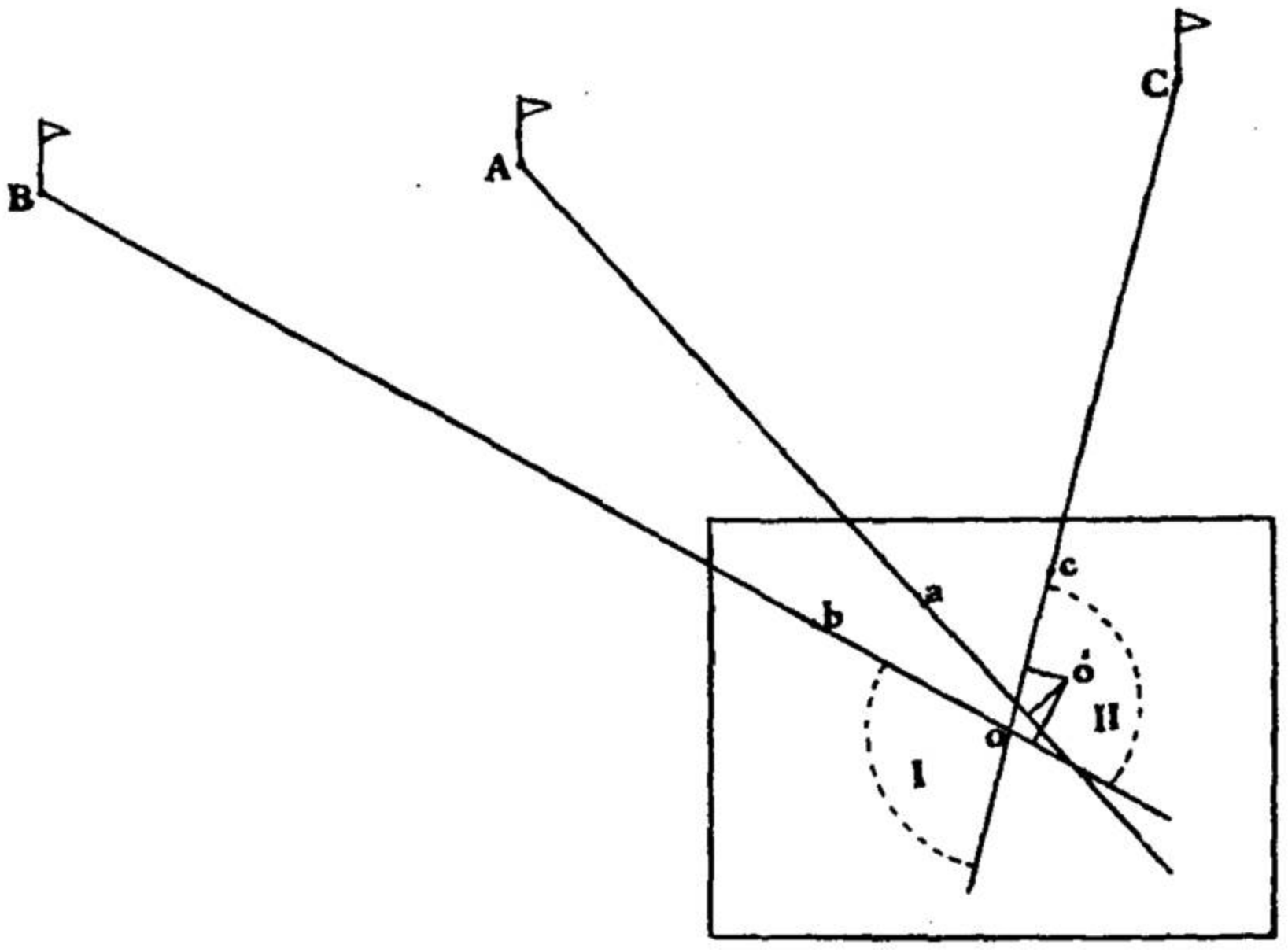
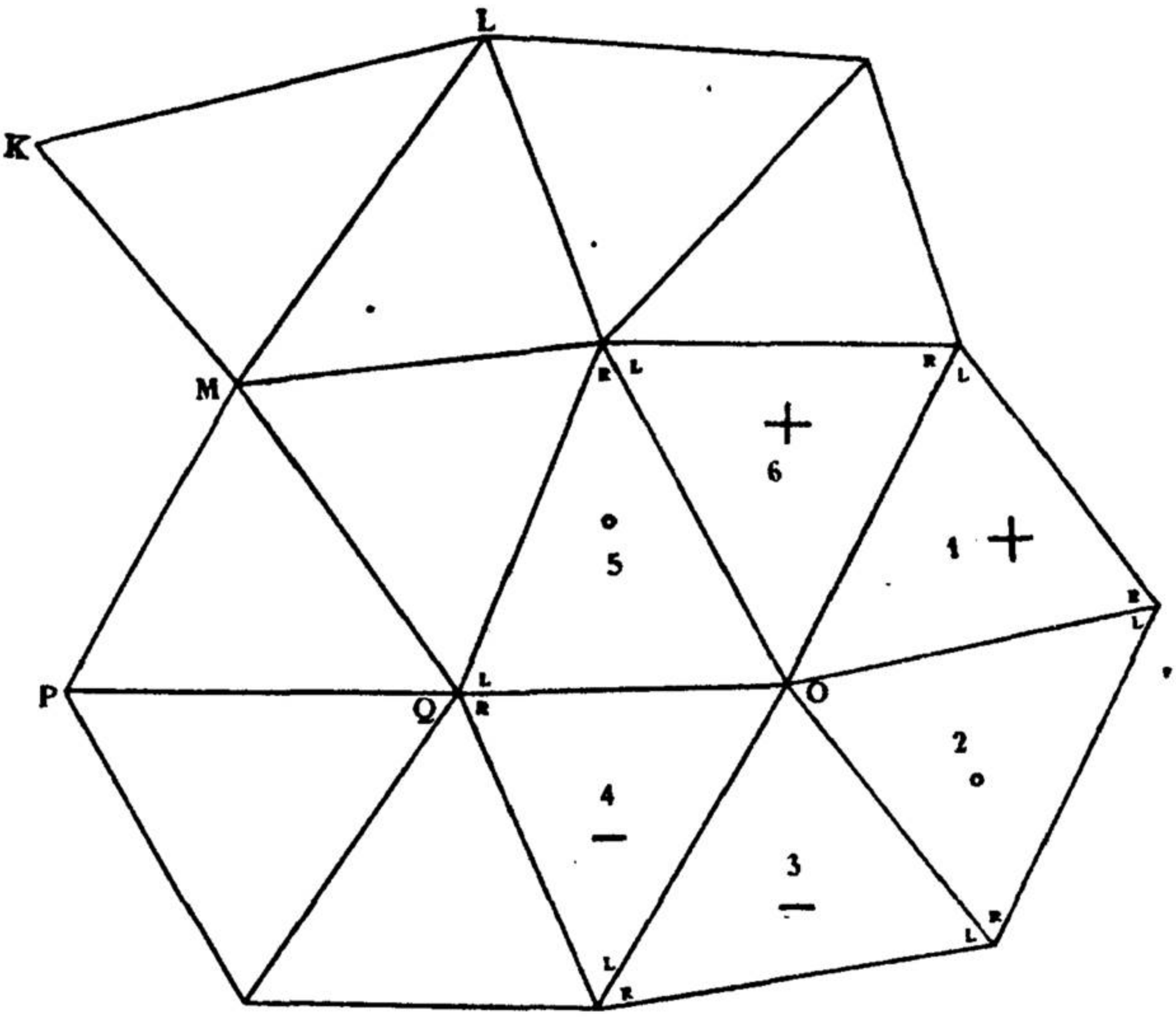
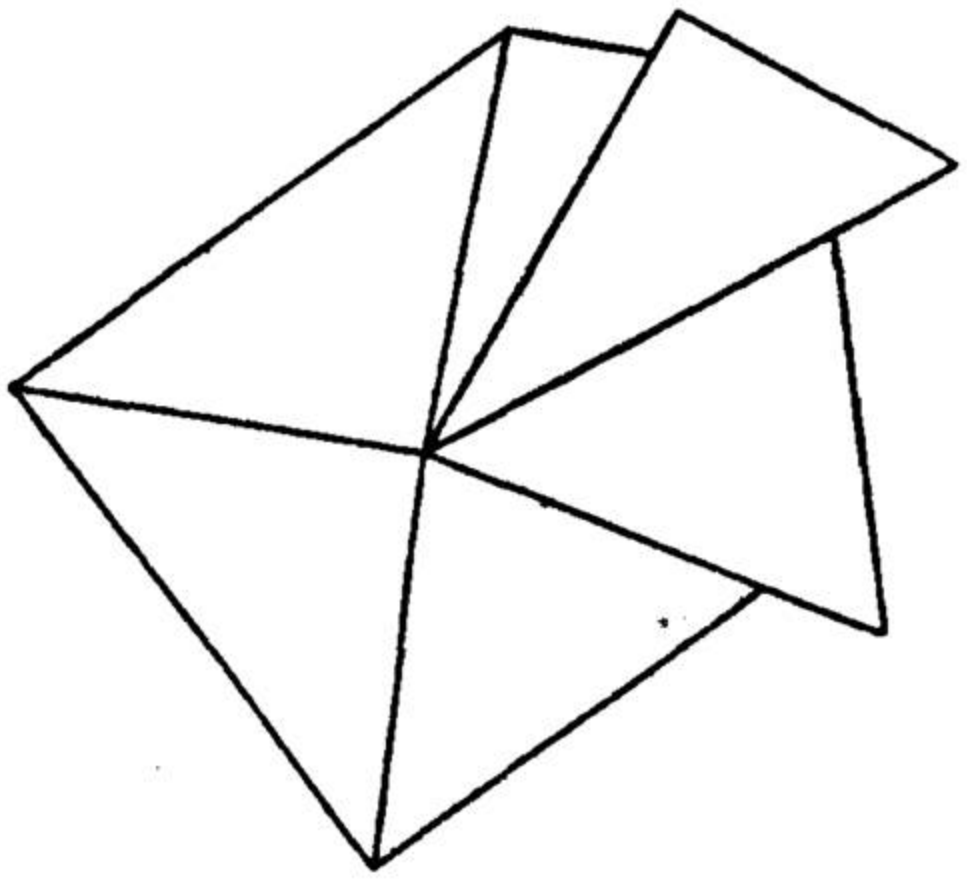


FIG. XLIV. (A) Page 88, Paras 1, 2 & 3.

Polygons.



(B)



(C)

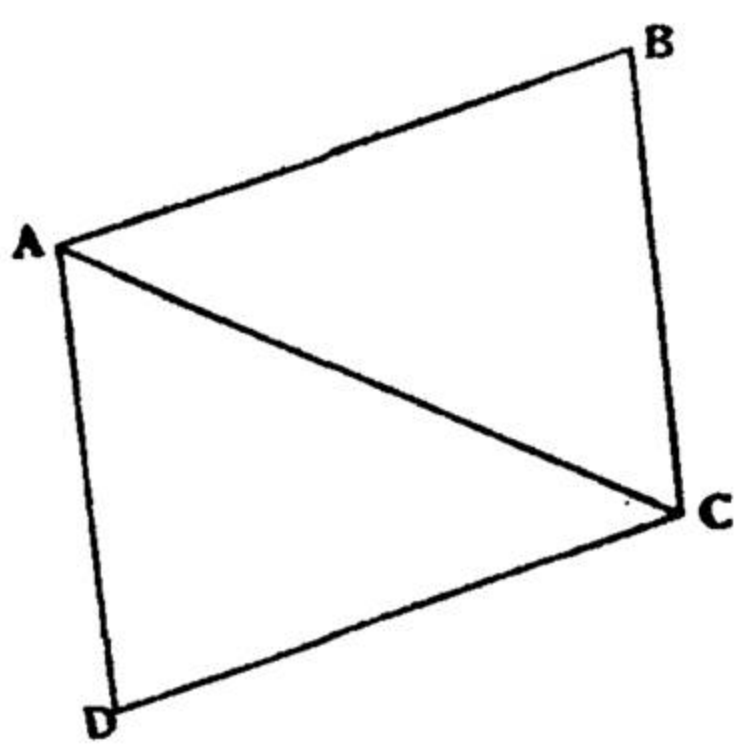
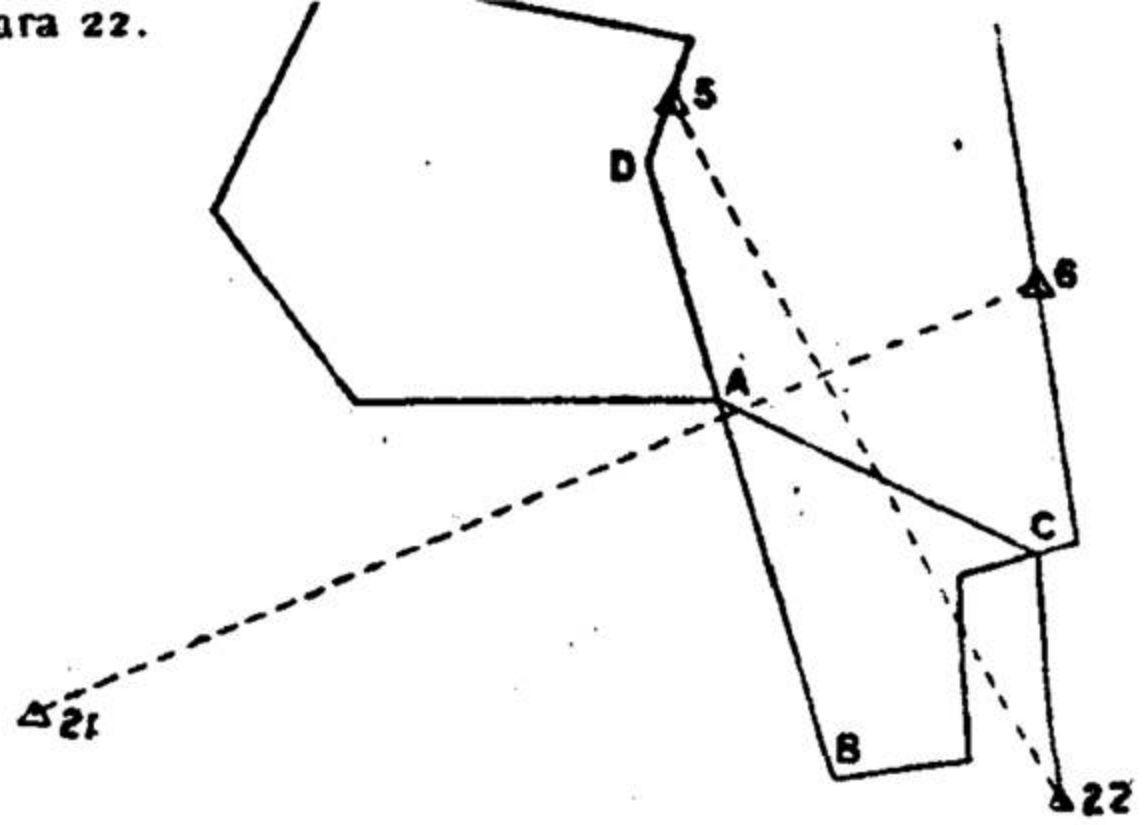


FIG. XLVII. Page 94, Para 22.



A Boundary Dispute.

It is alleged A has moved 5 ft northward; and he says that B has been moved.

1. Join 6-21 and measure offset to A.
2. Join 5-22 and ,, ,, ,,
3. Scale the distances from A to the (undisputed) points C & D.

FIG. XLVIII. Page 95, Para 28.

In this figure. The dotted lines represent perpendiculars dropped vertically through the earth, so that A B1 C1 is the plane area, while A B C is the actual.

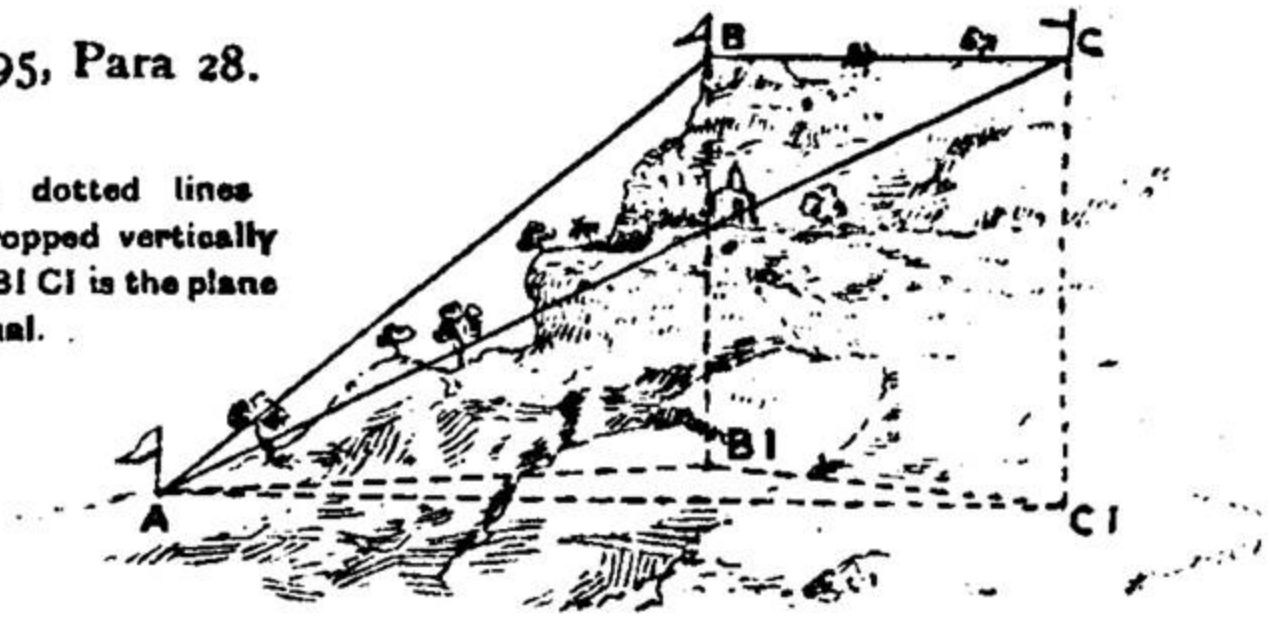


FIG. XLIX. Page 95, Para 29.

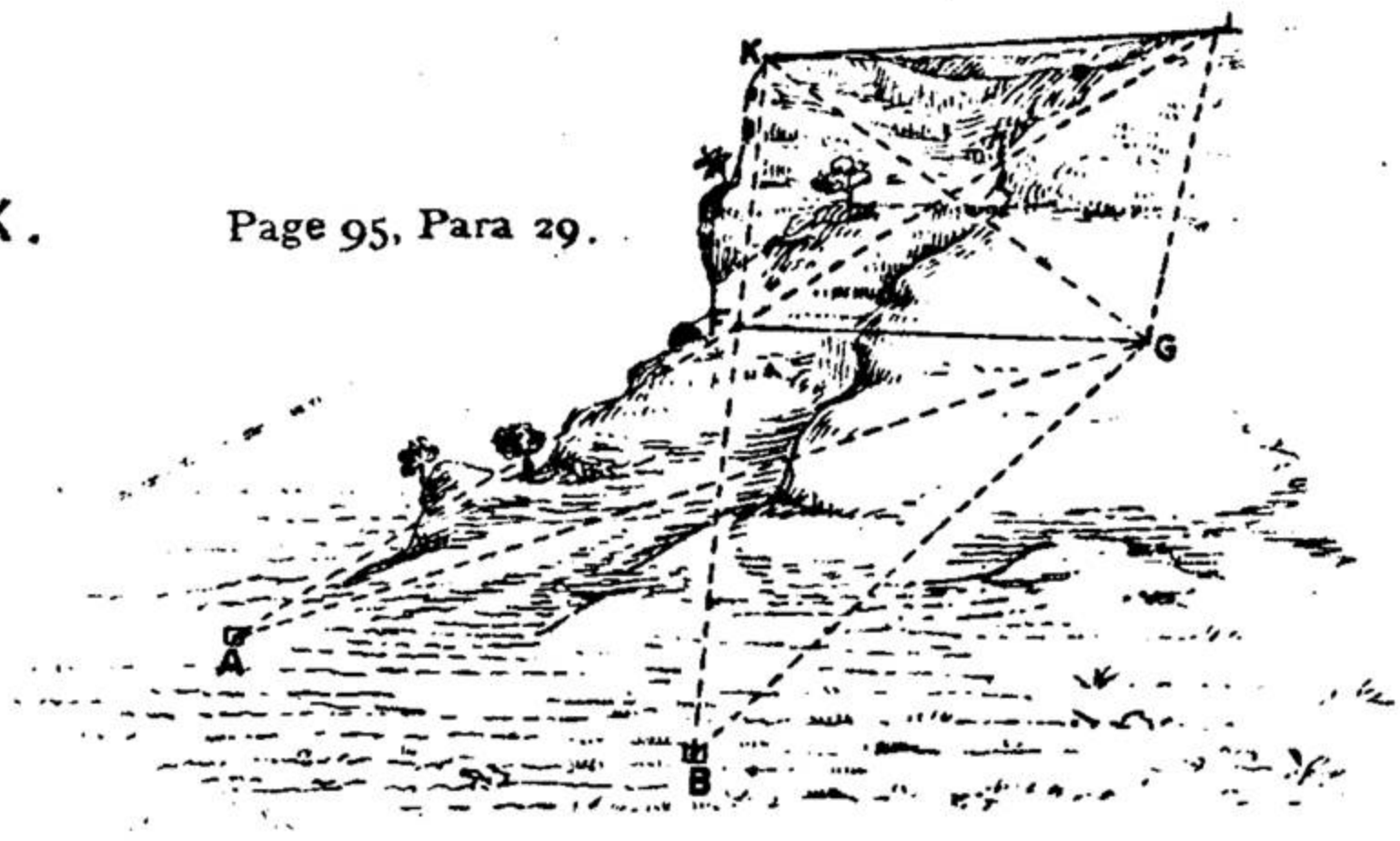


FIG. L. Page 96, Para 30.

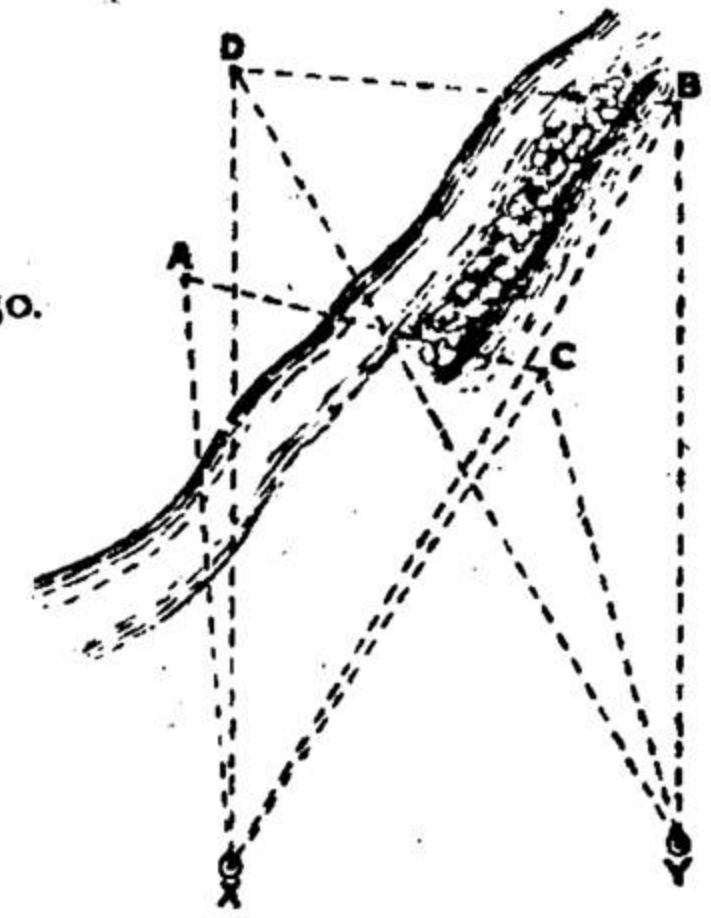


FIG. XLV. Pages 90 & 94. Paras 9 & 23

Derived Bases.

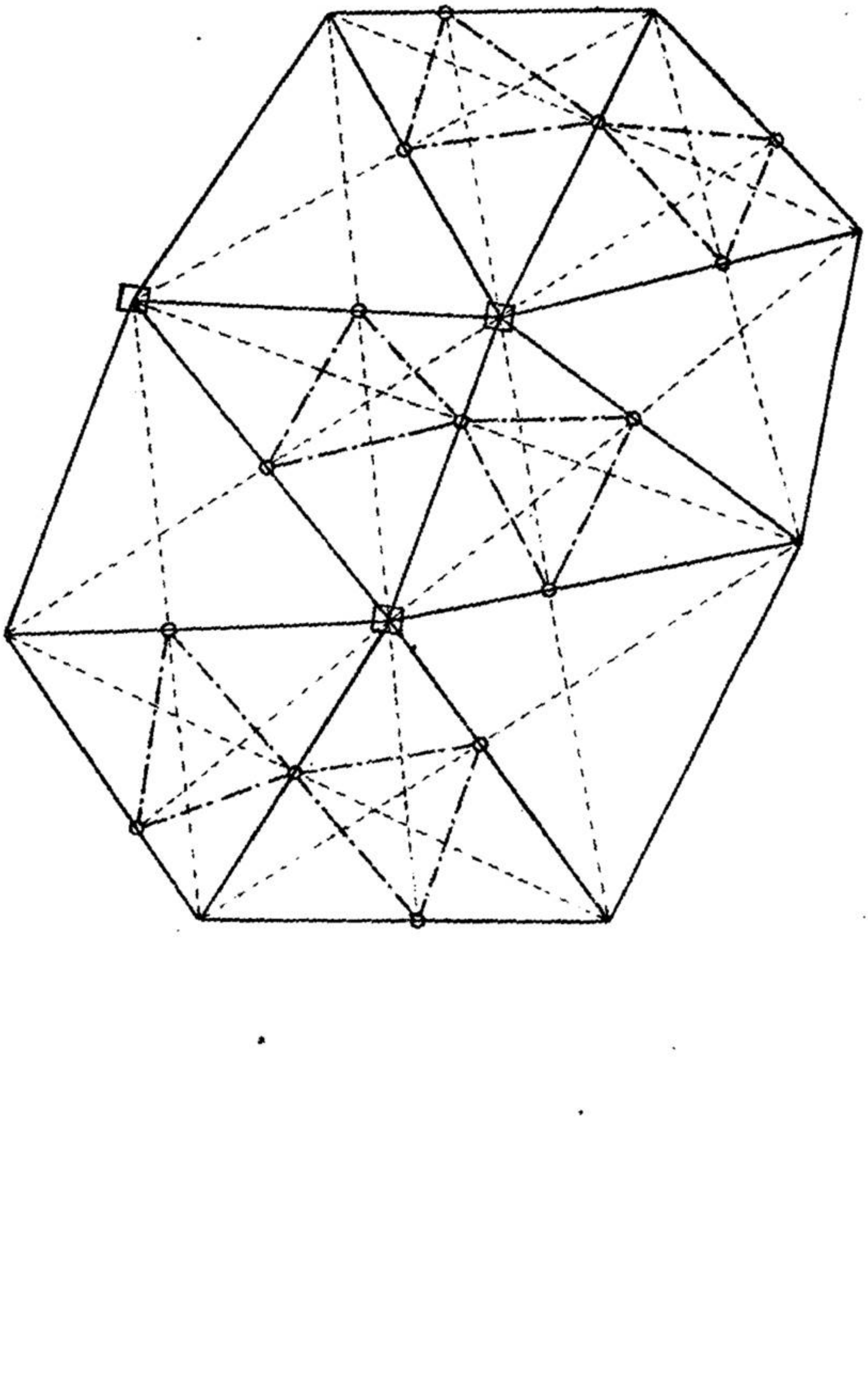


FIG. XLVI. Pages 91, 92 & 94, Paras 11, 13, 15 & 23.

Outline of a village Survey.