

Instruments



Plane Table

Instruments

- Plane Table with Tripod
 - Alidade (for sighting)
 - Plumbing fork with plumb bob (for centering)
 - Spirit level (for leveling)
 - Compass (for orientation)
 - Ranging rod (for location)
 - Drawing paper, pencil, etc.
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Plotting of graticule points

Suppose the scale of survey is 1 : 50,000. Draw a rectangular grid of 1,000 meters by a co-ordinatograph or with beam compasses. Draw a diagonal scale to read meters in one of the squares of this mesh. Plot the four corners of the graticule with the help of this diagonal scale. Join the four corners of the graticule and test the lengths of the sides.

Sub-divide the graticule and ink in with fine black lines. Enter the values of the co-ordinates in black ink near the margins of the board. The triangulated or traverse stations and points are, however, plotted from the rectangular grid lines. In the case of rectangular co-ordinates, no ambiguity can arise as

Plotting points

- All trigonometrical stations and points which fall within the area covered by the plane-table section, and all prominent points lying within the area of the board, are then plotted by a system of co-ordinates; stations, which are or will be treated as intersected points in the triangulation pamphlets, will be entered as intersected points. Points should always be plotted from the nearest graticule line. Testing should always be carried out by two men ; one should measure the position as plotted by co- ordinates and read out the result as found from the scale, which is then checked by the other against the list of stations and points. The necessity for extreme accuracy in projecting and plotting cannot be too strongly insisted on. Nothing tends so much to shake the confidence of the surveyors as errors due to carelessness in these respects, and many hours may be wasted in the field, if this preliminary work is found to be unreliable. The projection and a percentage of the plotting should, therefore, invariably be tested independently by an officer not below the rank of Surveyor or Survey Assistant, the remainder of the plotting being tested by a reliable surveyor, preferably the one who will carry out the survey.

List of Ground Control Points and Intersected points.

भारतीय सर्वेक्षण विभाग
SURVEY OF INDIA

Page. 4..

Station No. 16... PART PARTY (595577, 1730, 2051, ...) की न SEASON 1924-25

विश्व GRID-सि. {
λ. 10° 01'
L. 00° 00'

List of Grid Co-ordinates and Heights

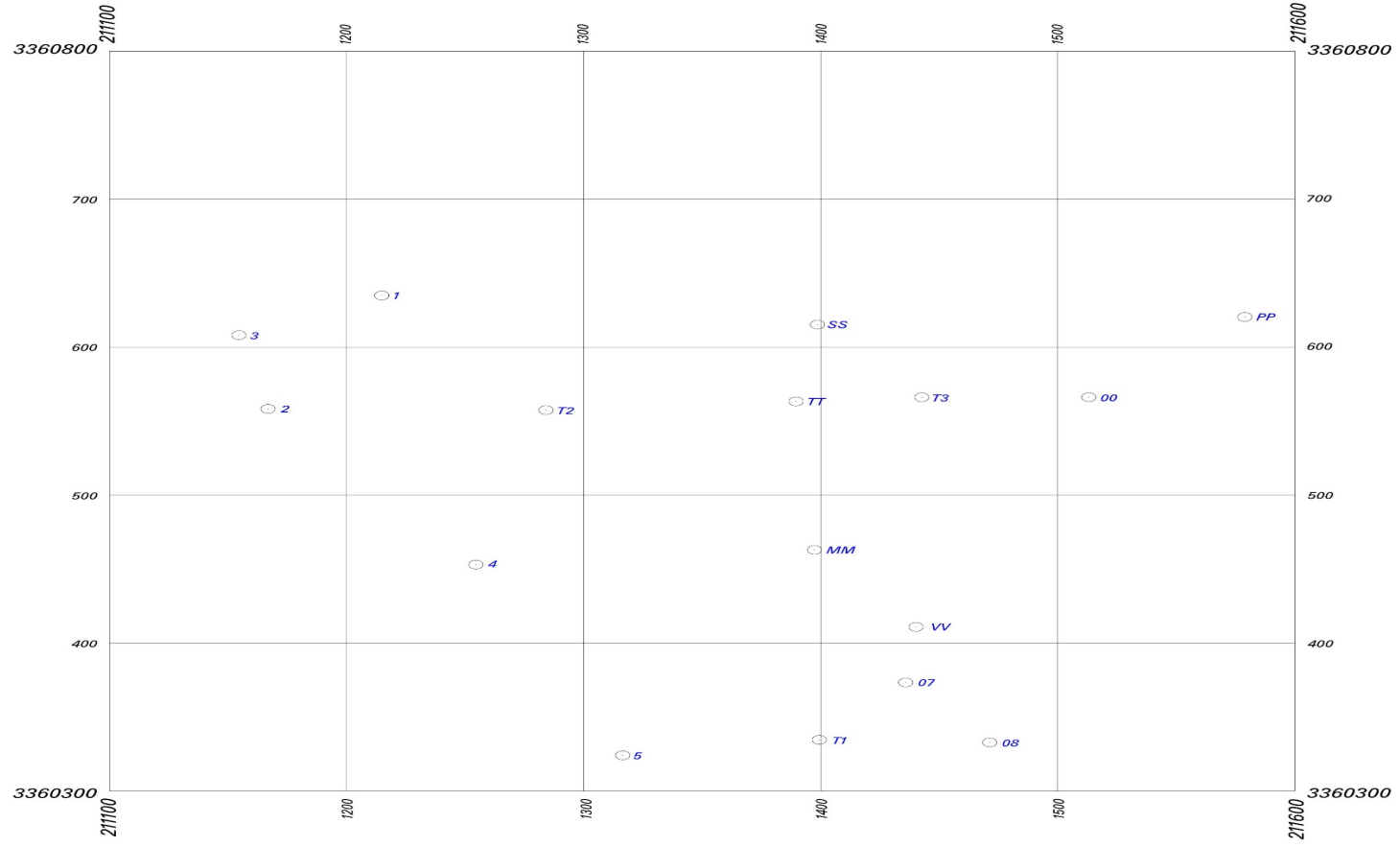
सर्वेक्षण विभाग द्वारा किये गये सर्वेक्षण की सूची

द्वारा BY K. K. SHUKLA, P.T.O.

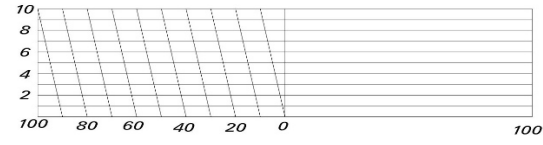
शीट No. 52, K/1

क्र. सं. No.	स्थान का नाम Station or point	उचाई Height	सर्वेक्षण द्वारा की गई Grid co-ords		सर्वेक्षण द्वारा की गई Grid co-ords		उचाई का अंतर [Height in meters]		
			उत्तर North	पूर्व East	उत्तर North	पूर्व East	सर्व General	शीर्ष Top	अंतर Difference
1	Rengandi h.s.		260 2097	431	729 907	391	51640		
2	Rengandi S		260 1998	40	728 632	42	509.95		
3	SS-7 (EDM)		260 3972	40	727 410	71	410.77		
4	Black hill cairn		260 3735	27	728 381	91	501.60		
5	TS-1 Traverse stations		260 22 24	02	72 86 20	26	506.78		
6	TS-2		260 24 40	05	72 85 66	38	500.18		
7	TS-3		260 27 64	29	72 84 36	82	487.60		
8	TS-4		260 31 55	09	72 82 81	04	476.59		
9	TS-5		260 30 13	67	72 80 77	89	468.16		
10	TS-6		260 34 54	05	72 77 44	99	464.57		
11	TS-7		260 35 69	33	72 76 18	60	457.42		
12	TS-8		260 38 54	64	72 75 61	97	456.40		
<u>INTERSECTED POINTS</u>									
13	I.P-1 (Cairn on top)	(A)	260 25 08	33	72 76 59	65	-	507.40	
14	I.P-2 (Cairn on black ridge)	(B)	260 25 74	65	72 83 82	01	-	502.70	
15	I.P-4 (Electric pylon)	(C)	260 36 67	90	72 70 58	66	-	480.71	

1:2000



Scale of Metres



○ Master

Preliminary accessory work

It is usual top priorities for the record slip, tabular forms for list of triangulation or traverse stations and name reference list, to be printed on the plane-table sections beforehand.

- If this is not done, the record slip will have to be pasted on, and the tabular forms ruled up, where they will not interfere with the work which will appear on the section, or with the border which will be subsequently drawn.

- **Table of trigonometrical stations and points.** The trigonometrical points plotted within the area of the work should be given serial numbers, which should be entered on the plane-table section and on the table, which should contain the name, coordinates and height of each point in descending order of latitude. The heights should be entered in the appropriate column in black, according to whether they are top or ground heights. The letter 'P' should be entered in black in the table against those stations and points which are of fairly permanent character.
- Reference table. This table will be prepared for the entry of reference numbers, names, etc.
- Surveyors will also be furnished with the following :—
- (i) Triangulation and traverse data of the points falling on their plane-table sections, both within and outside the area allotted for survey. Great care should be exercised that no points are omitted, and it should be remembered that the area of a map is touched on by eight other map areas which may contain points for plotting.
- (ii) Particulars regarding the positions and heights of all bench-marks falling in their work.

Methods of Plane Table Surveying

- **Radiation method** :- This method is suitable for small area. P.T. is set at commanding stations. Detail points are plotted on their radiating lines drawn from the location of instrument station.
- **Traversing Method** :- The P.T is set at each successive station, a foresight is taken to the next station and its location is plotted on foresight by measuring the distance directly between two stations.
- **Intersection Method** :- Location of other points are determined by drawing rays from each station after proper orientation of the table. The intersection of the rays gives the location of the details point.
- **Resection Method** :- the process of determining the location of the station occupied by the plane table , by means of drawing rays from stations whose location have already been plotted on the sheet. This method also called interpolation or fixing method.

Setting up the plane table

- Levelling the plane table :- levelling can be done by eye estimation. Fine tuning of levelling the plane table is being done by spirit level.
- Centering :- Location of the plane table station on the paper is brought exactly vertical above the ground station. For rough and small scale work , exact centering of the station, is not necessary.
- Orientation :- in this operation, P.T is set at a station such that its edges make a fixed angle with a fixed direction. The fixed direction of known as meridian. In case the table is not oriented properly, the location of detail point will not represent their correct relative positions.

PLANE-TABLING METHODS

General principles.—The plane-table should be levelled. This is specially important in hilly ground and in large scale surveys. When some of the fixed points are situated high above the observer, and some on the same level, or below him, a slight dishevelment of the plane-table will throw out the position of the fixing very considerably. It can be roughly ascertained whether a plane-table is level or not by dropping a pencil on the board a few times and noting the direction in which it tends to roll. A small spirit-level can be used to level the plane-table.

In soft and marshy ground, a firm footing may be obtained for the plane-table by driving in stout wooden pegs flush with the surface of the ground for the legs to rest on ; in loose sand, a certain amount of stability can be effected by inserting each leg of the plane-table stand into a block of wood with a hole drilled through it.

The pencil should be a hard one, and should be kept very sharply pointed, as fineness of line is absolutely essential to accurate intersection and "clean" sketching of detail; a small piece of fine grained sandpaper is useful for renewing the point of the pencil.

Working method of plane table survey

- The pencil should be a hard one, and should be kept very sharply pointed, as fineness of line is absolutely essential to accurate intersection and "clean" sketching of detail; a small piece of fine grained sandpaper is useful for renewing the point of the pencil.
- When making a fixing or intersection, rays should be drawn through the centre of the fixed point, and not tangentially to it. The blunt end of the pencil (with a little of the lead removed, so as to prevent smudging) should be used as a pivot for the sight-rule ; a pin should not be used, as pin holes photograph, and are also apt to cause blots when the section is inked up.
- When taking a ray, the pencil should be held as upright as possible, and at the same angle throughout, the point being kept pressed close to the edge of the sight-rule. If the sight-rule is at all bowed, special care must be taken to prevent the pencil running under its edge, and so deviating from the straight line. After checking with the pencil point that the sight-rule is directly over the pivoting point, a short ray should be drawn at the estimated position of the object aligned, which should be marked lightly with a small circle or with the appropriate symbol; it is sometimes also convenient to draw a third line at or near the edge of the board ; at this third line, a note of the object, or a slight sketch of it, should be entered.

Work at first station

- When commencing work, the surveyor should set up his plane-table on a prominent hill station, or well-fixed trigonometrical point situated in as commanding a position as possible, placing it level, and nearly over the station mark. He should then truly orient his board, by placing his ruler so that its edge passes through the point at which he is standing and the most distant visible point plotted on his board, and turning the table bodily round in azimuth until the true distant point is intersected by the sight-rule. This is commonly called "setting" the plane-table. He should next test the accuracy of all the trigonometrical points on his board by laying his sight-rule in their direction in succession ; if any found to be wrong, the plotting of them should be examined and corrected, if necessary, by reference to the data in his note-book.
- The necessary condition for the true orientation of a plane-table is that it should be in such a position that the north and south line on it shall correspond with the meridian, or, what amounts to the same thing, that the line drawn between any two stations on the plane-table shall be parallel to the line joining the same stations on the ground.

- The necessary condition for the true orientation of a plane-table is that it should be in such a position that the north and south line on it shall correspond with the meridian, or, what amounts to the same thing, that the line drawn between any two stations on the plane-table shall be parallel to the line joining the same stations on the ground.
- He should now place the compass, in its box, on some convenient part of the table outside the graticule, and shift it till the needle reads 0° , and then mark on his board with a firm pencil line the edge of the box. This position of the box should always be used subsequently for all ground nearly in the same meridian as that of the station at which the compass was set up.
- He should next draw rays to prominent and well-marked objects for the purpose of fixing them as auxiliary points. He should determine the height of his station from other close by triangulation stations and intersected points to check their heights and

Setting" by the back ray.—

- One of the methods of Betting the plane-table is by the method of back ray. The surveyor draws a ray from the plotted point or fixing to any forward point which he considers suitable to visit for the purpose of sketching. This ray should be produced, and its extremities marked on both edges of the table. On arrival at the forward point, he will place himself accurately on the ray from the last station, and will "set" his board by laying his ruler on the ray, and turning it round with the board until it intersects the last station. This is termed "setting by the back ray". It is independent of abnormal compass variations, but it is essential that the same edge of the sight-rule be always used. Rays now drawn from any other near trigonometrical points, if possible, on both sides of the setting ray, so as to intersect it, and preferably nearly at right angles, accurately determine the position of the surveyor.

Interpolation or Fixing.—

- The method most commonly used for setting the plane-table is by interpolation, or fixing by resection from known points; it is essential that the surveyor should be thoroughly familiar with this method, as most of his work is carried out by means of it; it has the great advantage of avoiding any accumulation of error, as each fixing is made independently, and depends solely on the triangulated or other fixed points.
- (a) Interpolation from two points after orientation by compass is not satisfactory, owing to the possibility of error due to any abnormal magnetic declination and inaccuracy of setting by a magnetic compass; and, when this method is unavoidable, it should only be used for the purpose of sketching detail, in the vicinity of the fixing, and not for extension.
- A satisfactory check can be got if a ray is drawn from the first interpolation to some object D (see diagram opposite) in a direction nearly parallel to the line joining the two fixed points, A and B and at a distance approximating to the distance between them. The surveyor then proceeds to D and, setting by the back ray, draws rays from the two points, A and B.

- These rays will, if the board has been truly oriented, intersect on the line drawn towards D from his first station. If they do not intersect on this line, accept; for the time being, the position given by the intersection of the ray from point A and the ray from the first plane-table.
- fixing, and draw a line towards the other point B ; it will meet the ray, drawn through B at the first station, at a point C.
- The board is out of orientation by the angle CAB, and may be corrected in the following way; place the sight-rule on the line AC, and pick up a distant object, then put the sight-rule on the line AB, and turn the board until the same distant object is intersected.
- The board is then truly oriented and the surveyor may resect his position and draw a ray towards his first station.
- Returning there, and setting by the new back ray, the resection from the two points should fall on the ray.

- During training, it is a good plan to take surveyors to a point exactly "on the circle" ; they will then find that for any orientation of the plane-table (within certain limits) all 3 rays will meet at a point.
- It is important, in regular work, to guard against the tendency to waste time by drawing rays to distant objects, whose position will be more easily fixed, later on, by shorter rays. The drawing of an excessive number of rays from one fixing leads to confusion on the plane-table, and occupies time which would be more usefully employed in making a second plane-table fixing elsewhere, and again drawing a moderate number of rays from that. This does not apply to reconnaissance survey, or survey carried out during military operations in a country, where the freedom of movement of the surveyor will always be restricted, and it is consequently of the utmost importance to get all detail fixed, even approximately, whenever and wherever the opportunity may offer.
- When surveying in the vicinity of the external frontier of India, the surveyor should include as much of the country across the frontier as he can, from fixing within the frontier; the courses of streams and the limits of water forms, which have not been surveyed with sufficient accuracy, should be indicated by broken lines ; and similarly, the hills should be shown by broken contour lines, so as to avoid giving the impression that the ground has been visited and rigorously surveyed.

In hilly country, it is usually best to commence work from the tops of the hills, and work downwards, rather than vice versa, as the extent of the country visible enables the surveyor, not only to see sufficient fixed points necessary for a good intersection, but also to draw rays to more items of detail than he can from low ground. The different topographical features should, however, be sketched, as far as possible, from stations of a similar altitude, as they assume a far truer relative value, when viewed from such points, than when seen either from far above or from below. It is always best to fix the position of detail on a slope from two or more fixings on an opposite slope, rather than from those on the slope itself. On the other hand, the shape of the ground, changes of slope, etc. can be better seen in profile than from an opposite

- point. Fixings on both sides of a main valley are, therefore, necessary ; and there will of course always be the necessity of making fixings on the low ground, in order to survey detail, which it has been impossible to fix from the higher and more distant plane-table stations ; but their number will be comparatively few, and their attainment, owing to the number of good plane-table points, which will already have been fixed in their neighbourhood, a matter of comparative ease. In the case of minor parallel side valleys, it will usually be sufficient to visit the alternate ridges, surveying the intermediate ridges by intersection from both sides.

- In densely wooded low ground, which is commanded by hills, it is frequently possible to fix points by sending men to light fires at the selected points, preferably with dead leaves, which make a good quantity of smoke. The surveyor then fixes the point of origin of the smoke by suitable intersection, and also gives a height to the tree tops at the point. Such points are invaluable for controlling traversing in the low ground.
- In wooded hills, where the cost and labour of clearing hill-tops would be prohibitive, a clear view of the country may often be obtained by building a machan in a tall tree. The upper branches should be cut off above a suitable fork, upon which the machan is constructed. A platform of small branches should be made and surrounded by a rail. If the trunk of the tree is devoid of branches, a pole or rope-ladder may be necessary.

Colours generally used.—

A drawing pen should be used as far as possible for inking in the detail, but, for ornamentation, dots and lettering, a crow quill or mapping pen will be found most suitable.

- The colours generally used on plane-table sections are follows :—
- Black .. Indian ink.
- Red .. Plane-tabling symbols in alizarin crimson, all other in vermilion.
- Brown .. Burn umber or burnt sienna
- Green .. Viridian
- Yellow .. Aureolin and yellow ochre.
- Blue .. Cobalt (where this has to be reproduced by photography, some alizarin crimson may be mixed with it).
- Do(for washes) .. Cobalt

- (a) Administrative boundaries in their appropriate symbols in black. The exterior boundaries of reserved and other forests should be shown by continuous green lines over the symbol.
- (b) Locality, tribal and range names, and their limits, in black, crimson and brown respectively.
- (c) All cultivated areas in a dark and complete yellow wash. The limits of this wash should be shown by cultivation dots, or the actual item of detail, e.g., path, boundary, stream, etc., which forms the limit on the plane-table section. Where, within the area of permanent cultivation, numerous bits of fallow land, and field bunds below 2 metres in height exist, and have not been surveyed, the following note should be entered across the area in addition to the yellow wash :
—Periodical cultivation dependent on rainfall; numerous field bunds of less than 2 metres in height Field bunds of 2 metres and over in height will be shown on the plane-table sections in the usual manner.
- (d) All blue detail in strong colour.
- (e) Trees, undergrowth, grass and scrub in the appropriate symbols in black, the closeness of the symbols indicating the density of growth. Undergrowth and scrub should be represented by dots of varying sizes; the sparing use of irregular half-circles, as shown in the symbol tables is permitted where scattered dots do not give sufficient prominence. Vegetation in hilly areas, which is not drawn on the plane-table section, should be drawn on the trace, on the ground by the plane-table. In jungle areas where the vegetation will appear as a green tint on the published map, the area will be drawn by a green wash on the trace and the type of vegetation and density written in appropriate places.

Survey of boundaries

- The survey of boundaries requires special care on the part of the surveyor and his supervising officers, and no plane-table section should be passed until the boundaries have been carefully checked in the field by an officer, and compared by him with the existing maps and descriptions. It is very important that the boundary should be correct with regard to local detail as well as strictly in position with regard to the graticule.
- All boundary pillars should be entered either as surveyed or with the symbol indicating a pillar not found on the ground. If pillars which are shown on previous maps, or described in the written description of the boundary, cannot be found on the ground, then the camp officer must record the fact for the information of the wing in charge of the wing. Whenever the cairns are pulled down to identify pillars, they must be rebuilt at once ; no pakka pillar is ever to be injured for such a purpose. All pillars found must be described by their proper numbers if numbered, and their descriptions recorded in the village lists.
- In the case of boundary which has already been accurately traversed or surveyed, the alignment may be taken from reductions of cadastral maps, or other accurate maps or data and accepted after surveyor has satisfied himself, by testing it at occasional points, that its geographical position is correct.
- Where a boundary has not previously been accurately surveyed, all possible information should be given to the surveyor who should be told whereabouts to look for the boundary pillars and be given a general description and approximate line, based on the best information available. The boundary will then be accurately surveyed, throughout its length, where it is demarcated or where it has been ascertained, either from maps or description, or by reference to local authorities, to follow natural features ; where it follows arbitrary alignments, the local authorities must be asked to point them out to the surveyor, and if in jungle, to clear them. In the case of a difference of opinion, the alternative boundaries, as pointed out by different authorities, should be surveyed and the matter referred to the proper authority.

Boundary pillars

- The symbol for a boundary pillar is a solid black square ; the position of any boundary pillar not found at the time of survey should be shown in the position originally assigned to it, by an open black square, and a note be made on the plane-table section to that effect.
- When a boundary pillar occupies the same position as a trigonometrical or traverse station, or intersected point, the symbol for both should be shown.
- International and State boundaries.—All boundary pillars marking the external boundary of India and boundaries of states, should be shown, and the numbers marked on them should be entered on the plane-table section. When the number happens to be in Roman figures, it is admissible, when such numbers extend to great length (e.g., LXXXVIII), to print them in Arabic figures so as to avoid interfering with detail, but the numbers in anyone plane-table section should, as far as possible, be in the same style.