

## Chapter -2 Plane Table surveying

### 2.0 Plane Table Surveying

Plane table surveying is a graphical method of surveying in which field observations and plotting of the plan can be done simultaneously in the field. In case of plane table surveying Geometrical conditions of site are manuscript in the map sheet using plane table and alidade after that topographic details are arranged on the map. The plane table surveying is the fast method of surveying. There is less chances of missing details at the time of surveying in the field. The office work is not necessarily required. The plane tabling is generally adapted for surveys in which high precision is not required. It is mainly employed for small-scale or medium size mapping.

### 2.1 Principle of Plane Table Surveying

The law of plane tabling is parallelism, meaning the rays drawn from stations to items on the paper are parallel to the lines in the stations to the objects on the ground. The relative positions of these objects on the ground are represented with their own plotted positions about the paper and lie on the respective rays. The table is always placed at each of the successive stations parallel into the position it occupied in the starting station. Plane tabling is a graphical way of surveying. The fieldwork and plotting are done simultaneously, and this survey doesn't involve using a field book (measurement book). Sometimes traversing with a plane table might also be done. However, this survey is recommended for the work where great accuracy isn't required. As the fixing and fitting arrangement of this instrument is not perfect, most accurate work cannot be expected. The simplest and the most commonly used plane table is as shown in as per below figure. It is known as a traverse table. It consists of a board made up of a well-seasoned wood mounted a light tripod with suitable mounting and clamping devices. The board can rotate about a vertical axis and can be clamped in any position. The table is to be leveled by adjusting the tripod.



## 2.2 Accessories/ Instruments Used in Plane Table Surveying:

The equipment needed in plane table surveying is straightforward and almost available everywhere. Following are the plane table survey instruments.

### 1. Drawing Board:

It is made of well seasoned wood. It varies in size, the common sizes are from 40 cm x 30 cm to 75 cm x 60 cm or 45 cm square, 60 cm square, etc.

The board may be mounted on a tripod with a leveling head or a ball-and-socket arrangement in such a fashion that it can be leveled and revolved about a vertical axis and may be clamped in any position.



**NOTE:** The head of the tripod may sometimes be provided with a light metal frame carrying three milled-headed screws to level the table.

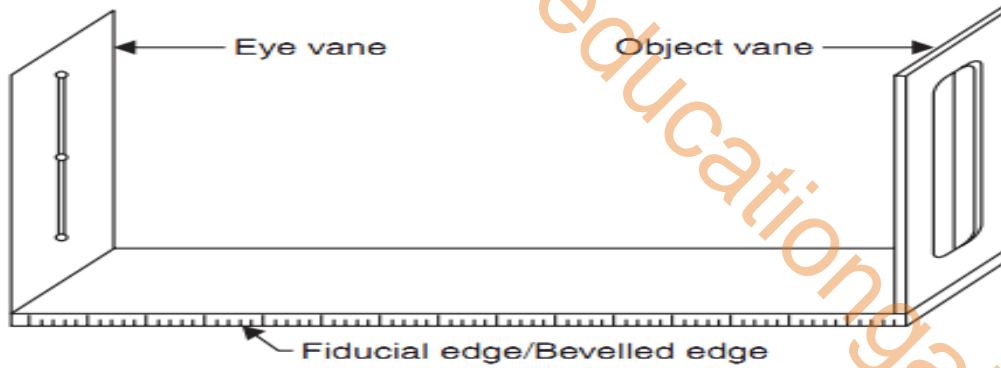
### 2. Alidade

The alidade is a ruler with a sight line attached and is used on the plane table for bisecting the object, drawing rays, direction lines, etc.

It consists of a metal (brass or gunmetal) or boxwood straightedge or ruler of about 45 cm long. The beveled edge is called the “ruling edge” or the “working edge” or the “fiducial edge.”

The alidade may be plain fitted with sight vanes at both the ends, or it may be equipped with a telescope.

One of the sight vanes is provided with a narrow rectangular slit. While other is provided with a central vertical hair or wire.



If the alidade is telescopic, the telescope is provided with a vertical circle, and a level tube is fitted with cross-hairs.



### 3. Spirit level:

If the spirit level which may be very sensitive, is not fitted to the alidade, the table can be leveled by placing the spirit level in two positions at right angles to each other and setting the plane table such that the bubble is central in both positions.



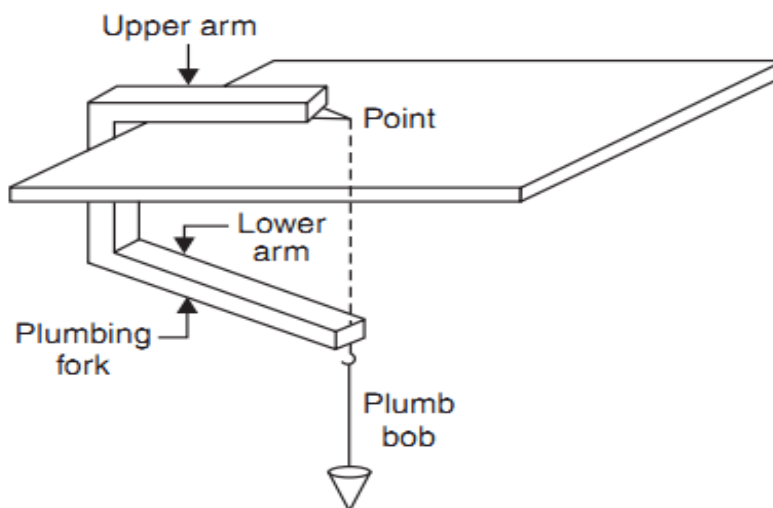
#### 4. Trough Compass:

Trough Compass with two bubble tubes at right angles to each other mounted on a square brass plate is used for indicating the direction of the magnetic meridian on the paper.



#### 5. U-Frame or Plumbing Fork:

A plumbing fork with a plumb bob attached to one end is used for centering the table at a particular station. This is used in large-scale work for setting the table such that the point on the paper (representing the instrument station being occupied) may be brought vertically over the station marked on the ground.



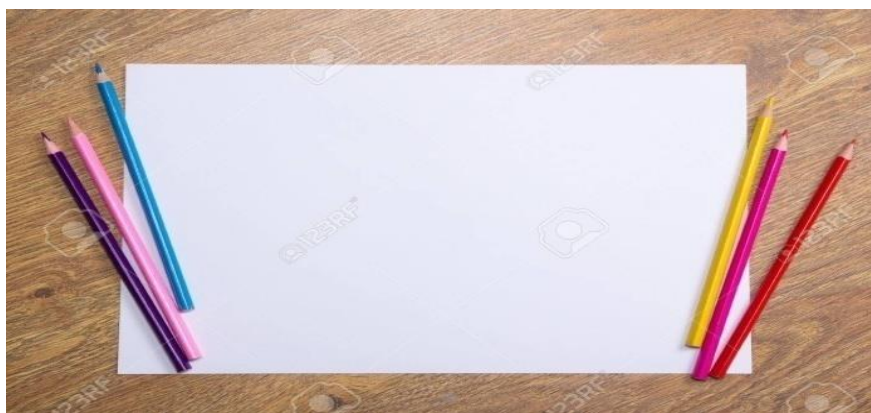
**6. Water Proof Cover:**

The Waterproof cover is used to protect the sheet of paper on the plane table from the rain.

**7. Paper or Drawing Sheet:**

The paper used for plotting the survey on the plane table should be of excellent quality because it is very sensitive and liable to changes due to the variation of humidity of the atmosphere. The paper expands and contracts in different directions with different amounts which consequently alters the scale and distorts the map.

The sheet should be well seasoned for about a week by exposing it alternately to damp and dry atmosphere. This treatment reduces its tendency to distort. The sheet should never be folded. Zinc and celluloid sheet is used for plane table surveying in damp climates. The paper may be fixed on the drawing board by using drawing pins or by pasting the edges. Besides these, the other drawing instruments like a pencil, rubber, scales, etc., are also required for plane table survey.





### 8. Tripod:

Tripod is also required for plain table survey. It is in one of the important plane table survey instruments without it is impossible to do plain table survey.

Tripod is used to fix the drawing board. It consists of a screw at the bottom which is used to set and level the drawing board on it comfortably.



**Ranging Rods:** A ranging rod (or range rod) is a [surveying](#) instrument used for marking the position of stations, and for sightings of those stations, as well as for ranging [straight lines](#)

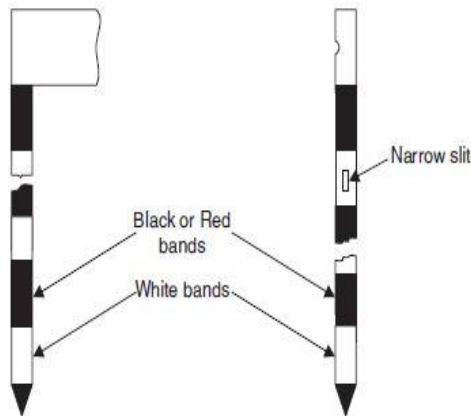


Fig. 12.7 Ranging rod

Fig. 12.8. Offset rod



## 2.3 Working operation of Plane Table surveying

The setting up of the table includes Four operations,

- (1) Fixing of the plane table
- (2) Leveling the table;
- (3) Orienting the table; and
- (4) Centering the table,

### (1) Fixing of Plane Table

Fix the plane table to the tripod stand. Arrange the drawing sheet on the plane table using paper clips or thumb screws. The sheet should be in one position from first to last.

### (2) Leveling:

The plane table should be set up at a convenient height (nearly a meter) by spreading the legs to keep the table approximately leveled above the particular station. The leveling is then completed by using of leveling screws (if provided) or by tilting the board by hand if the instrument has a ball and socket arrangement. A level tube or circular level is placed on the table first parallel to two screws and then over the third screw. If the leveling or the ball-and-socket arrangement is not provided, the leveling may be completed by simply adjusting the legs.

### (3) Orientation:

Orientation may be defined as the operation keeping the table at each of the successive stations parallel to the position occupied by the table at the first station.

Thus, all the lines on the paper will be parallel to the corresponding lines on the ground if the table is oriented. This operation becomes necessary in case of more than one instrument stations. If orientation is not done, the board would not be parallel to itself at various instrument stations and the plan would be obtained by using a different meridian at each station, and the relative plotted positions of various points in the area will be quite different from the actual ones. There are two methods of the orientation of the table. They are:

(a) By back sighting and (b) by magnetic needle.

**(3) Centering:** i.e (the point on the paper representing the station being occupied should be vertically above the point on the ground).

Centering is an essential step in plain table survey. The centering means to set the table vertically on the ground point. To perform this operation, place the pointed end of the upper leg of the fork coinciding with the point on the paper and suspend a plumb-bob from the lower leg and shift the table body until the plumb-bob of the fork hangs precisely over the center of the station peg.

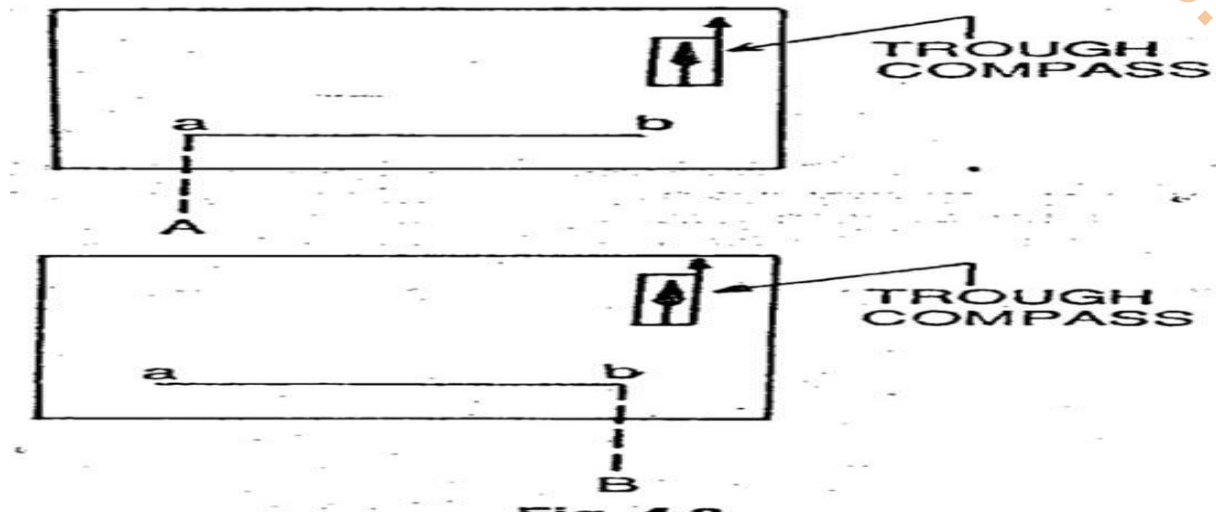
## 2.4 Orientation of Plane Table surveying:

Orientation may be defined as the operation keeping the table at each of the successive stations parallel to the position occupied by the table at the first station. Thus, all the lines on the paper will be parallel to the corresponding lines on the ground if the table is oriented. This operation becomes necessary in case of more than one instrument stations. If orientation is not done, the board would not be parallel to itself at various instrument stations and the plan would be obtained by using a different meridian at each station, and the relative plotted positions of various points in the area will be quite different from the actual ones. There are two methods of the orientation of the table.

(a) By magnetic needle/compass.

(b) By back sighting and

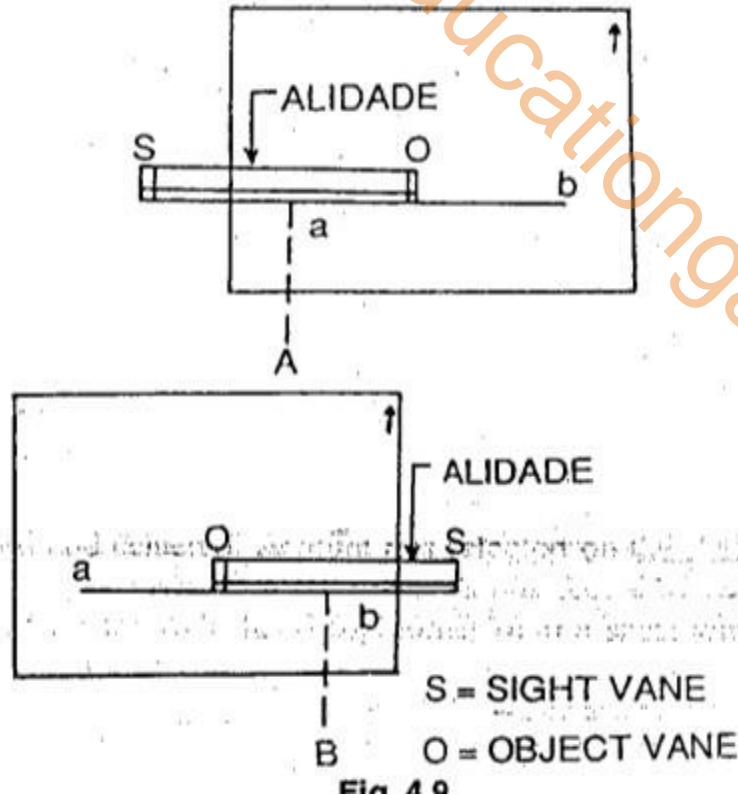
**Orientation by magnetic needle-** This method is suitable when a local attraction is not suspected in an area.



- suppose A and B are two stations. The plane table is set up at station A and levelled by spirit level. The centre is done by U fork and plumb bob so that point a is just over A. Then the trough compass or circular box compass is placed on the right-hand top corner of the sheet in such a way that the needle coincides with O-O mark. After this, a line representing the north line is drawn through the edge of the compass box the table is then clamped.
- With the alidade touch point, a ranging rod at A is bisected and ray is drawn. The distance AB is measured and plotted on any suitable scale.
- The table is shifted and centred over B, so that point b is just over B. the table is levelled now through compass, is exactly along the north line drawn previously. The table is then turned clockwise or anticlockwise until the needle coincides exactly with the o-o mark of the compass. While turning the table care should be taken not to disturb the centring. In case it should be adjusted immediately.
- When the centring and levelling are perfect and the needle exactly at o-o the orientation should be perfect.



**Orientation by Backsight-** This method is always accurate and it is always preferred.



- Suppose A and B are the two station. The plane table is set up over A. the table is levelled by spirit level and centre by U fork so that point a is just over a station A. the north line mark on the right-hand top corner of the sheet by through compass.
- With the alidade touching a the ranging rod B is bisected and ray is drawn. The distance AB is measured and plotted on any suitable scale.so the point b represent station B.
- The table is shifted and set up over B . it is levelled and centre so that b is just over B. now the alidade is placed along the line ba and the ranging rod A is bisected by turning the table clockwise or anticlockwise. At this time centring may be disturbed and it should be adjusted immediately if required. When the centring, levelling and bisecting of ranging rod A is perfect then the orientation is said to be perfect.

## 2.5 Methods of plane table surveying:

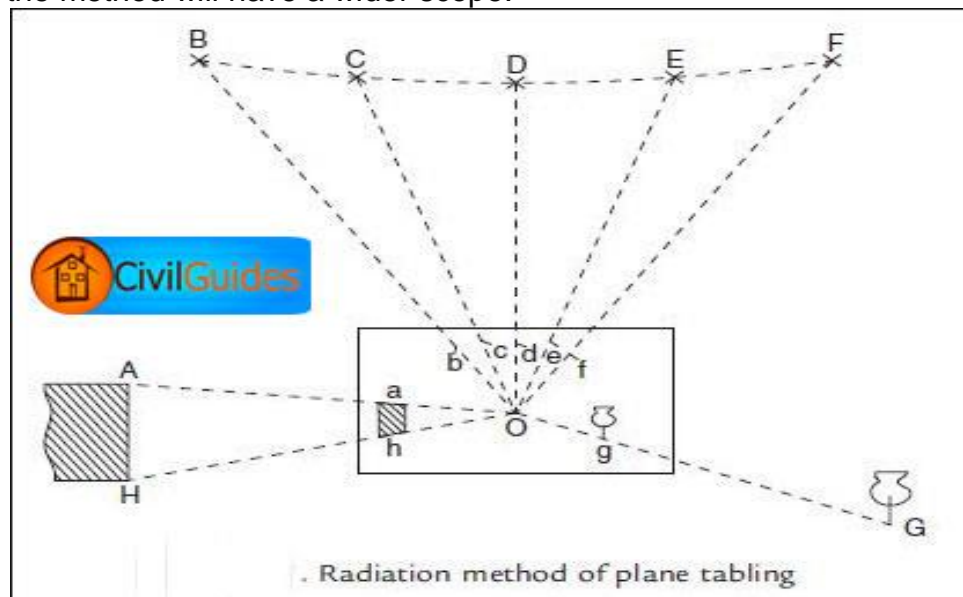
There are mainly four methods of plane table surveying, radiation, intersection or triangulation, traversing, and resection.

### (1) Radiation method of plane tabling:

In this method of plain table survey, the plane table is set up at only one station, and various points are located by radiating (drawing) a ray from the instrument station to each of the points, and plotting to scale along the ray the distance measured from the station to the point is sighted.

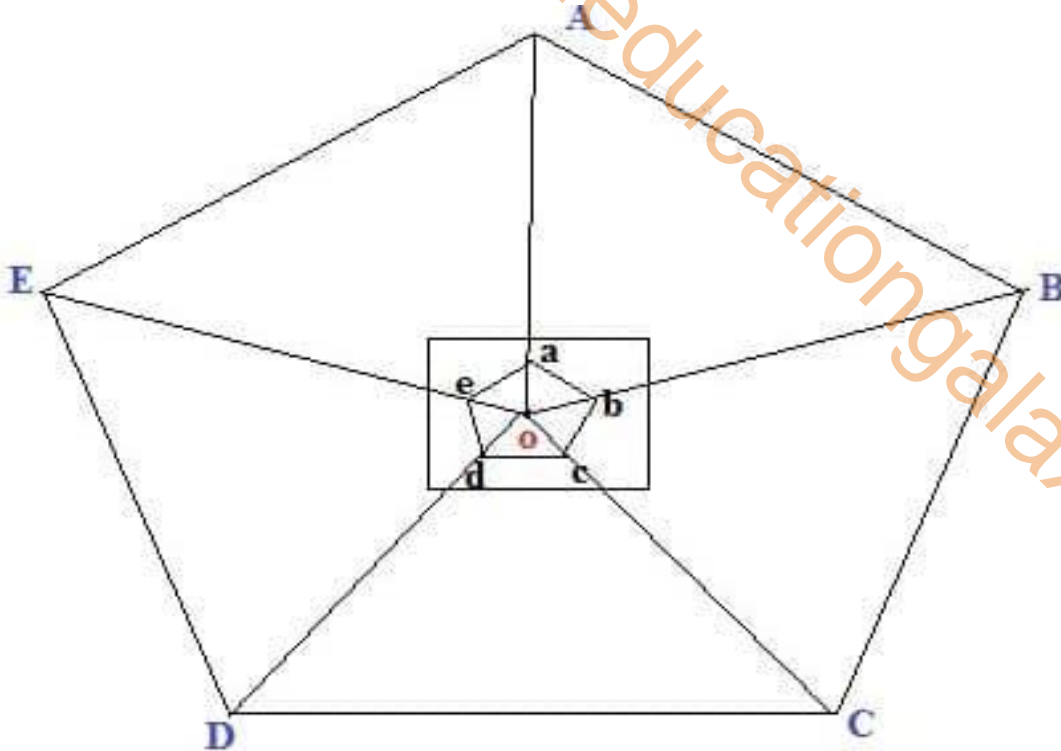
The radiation method is suitable for surveys of small areas which are likely to be commanded from a single station. It is useful in large-scale works if used in combination with other methods.

If the distances are obtained tacheometrically with the help of telescopic alidade (provided with stadia-hairs), the work can be finished very rapidly and thus, in this case; the method will have a wider scope.



### Procedure of Radiation Method of Plane Table surveying

In this method, plane table is located at one point "o" as shown in fig. and perform the whole from that point. From point O, sight the points A,B,C,D and E using alidade, locate and plot the points as a,b,c,d and e in the drawing sheet.



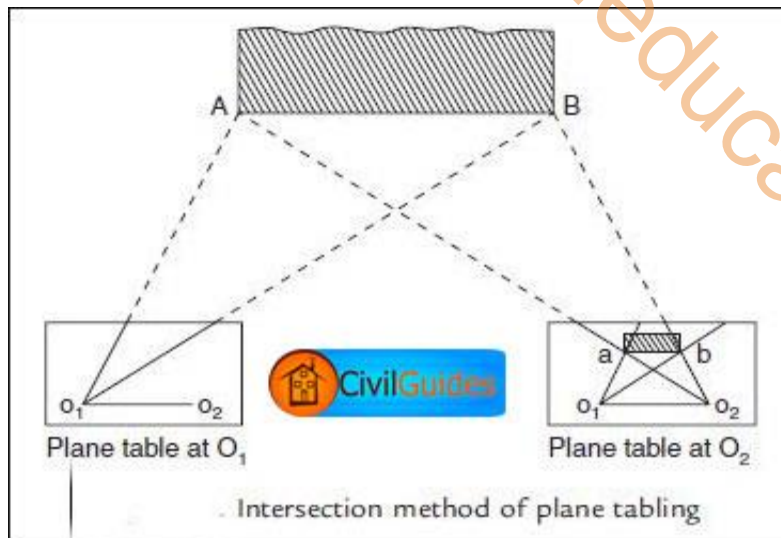
## (2) Intersection or triangulation method of plane table surveying:

This method is widely employed for plotting the details on the maps. It can also be used for plotting the position of points to be used at subsequent stations.

The various points can be located by the intersection of rays drawn from two different stations (A and B) forming a baseline.

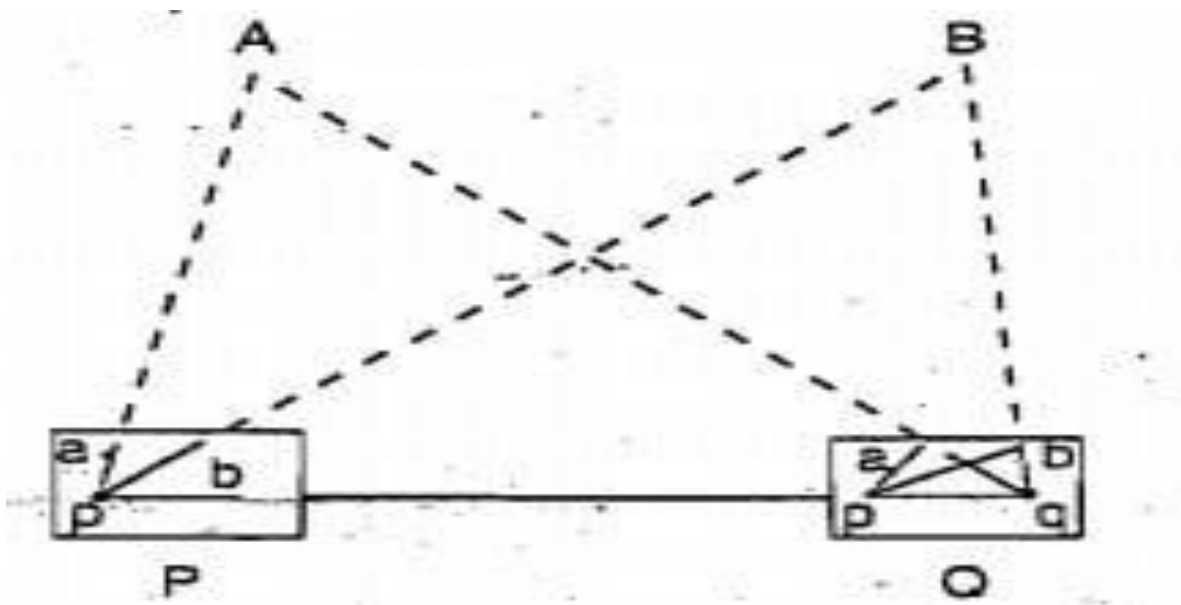
The only linear measurement required is that of the baseline AB on the ground.

The method may also be employed for locating the distant and inaccessible objects, the rivers, in a survey of the hilly areas (where distances cannot be measured easily), and for checking the remote objects.



### Procedure of Intersection Method of Plane Table surveying

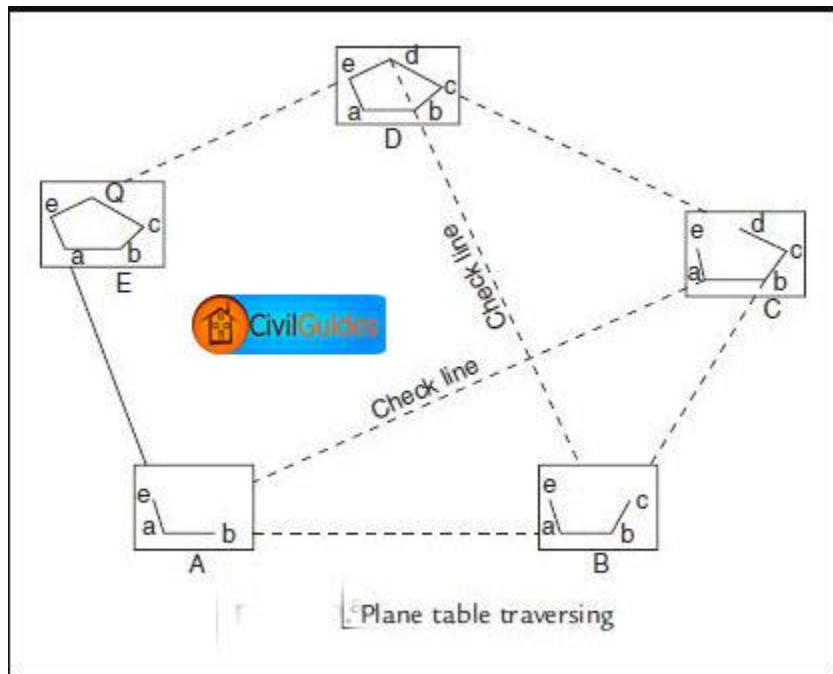
In this method we can locate the point by plotting two rays from two known stations. As shown in figure, P and Q are the known station. First the equipment is placed on P and plot the lines by sighting the stations A, B and Q. then shift the equipment to station Q and plot the lines by sighting stations A, B and P. Finally, the intersection of A and B rays is the required location of point of intersection.



### (3) Traversing method of plane table survey:

Traversing by the plane table is similar to compass or theodolite traversing. The method, therefore, can be used for laying down the survey lines of a closed or unclosed traverse.

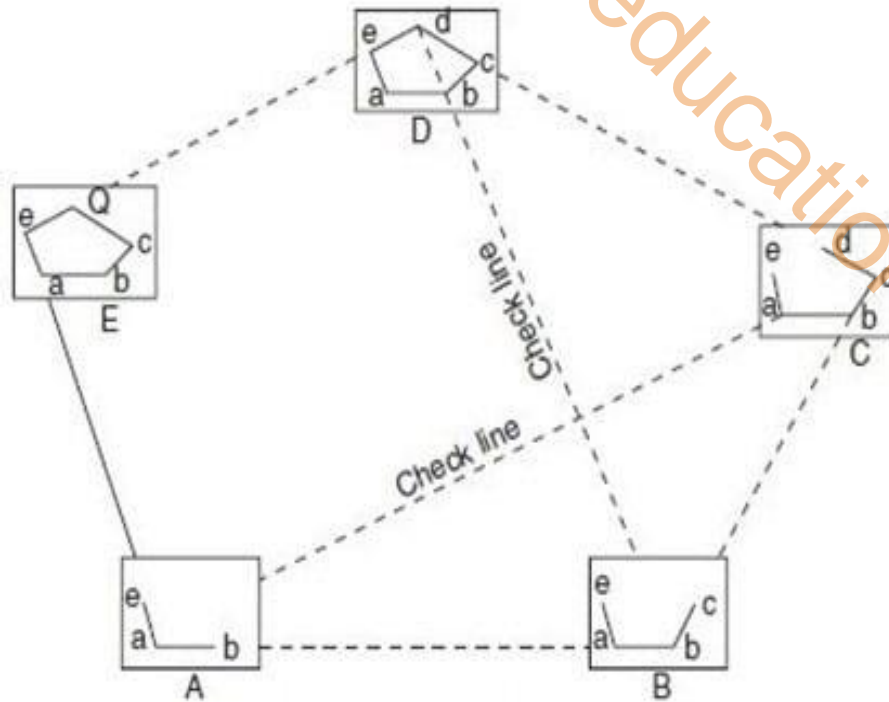
The details may be plotted in the usual way by taking offsets. The plane table traversing is also useful for the survey of roads, rivers, etc.



### Procedure of Traversing Method of Plane Table surveying

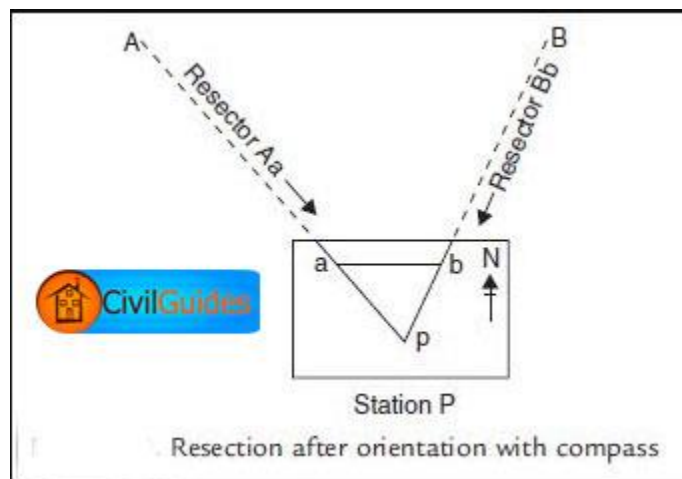
Traversing is the connection of series of straight lines. In case of traversing, plane table is located at one point for suppose A as shown below. From that point sight towards B and measure the distance AB. Then shift the plane table to point B and sight towards A and measure BA. Average distance of AB and Ba are plotted to scale in drawing sheet. Then Sight the point C from B and measure BC and repeat the same procedure until last point. Conduct some checks at some points. Finally traverse lines are plotted on the drawing sheet.





#### (4) Resection method of plain table survey:

The method of resection is employed for the location of station points only. After establishing the stations, the details are located by either radiation or intersection.



The main feature of this method is that the point plotted on the sheet is the station occupied by the table. Only one linear measurement is required as in the intersection method of plane tabling.

## 2.6 Introduction of Resection method of plain table survey:

Resection is a method of plane table surveying in which location of plane table is unknown and it is determined by sighting it to known points or plotted points. It is also called method of orientation and it can be conducted by two field conditions as follows.

- The three-point problem
- The two-point problem

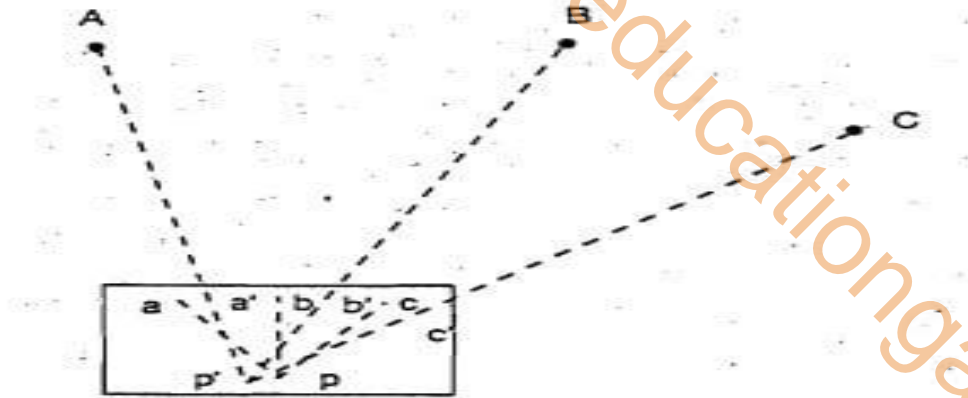
### The Three Point Problem

In this condition, three points and their positions in the field are known. Plane table is placed at apposition from where all the three points are visible. So, by sighting those three points we can locate the point where equipment is located. This can be achieved by many methods as follows.

- Tracing method
- Lehmann method
- Analytical methods
- Graphical method

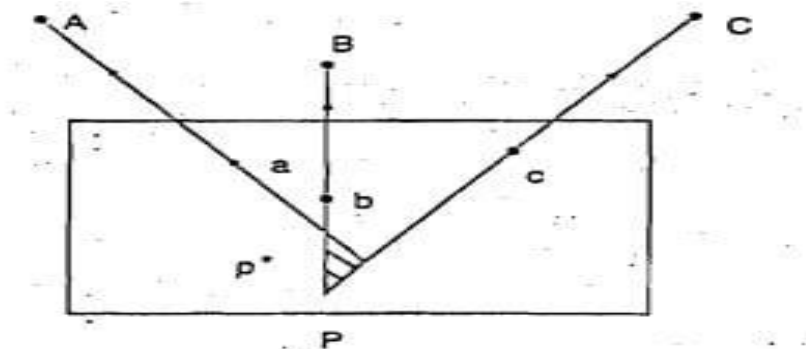
### Tracing Method in Plane Table Surveying

In tracing method, plane table is located at a point from where three points are visible. The table is oriented with respect to the plotted lines of those three points. Place the tracing paper on the drawing sheet and again sight the three points and plot the radiating lines. The tracing paper is then moved above the drawing sheet until the three radiating lines pass through corresponding points previously plotted on the map. Finally, the position of plane table is marked.



### Lehmann Method

In this method, Plane table is located at a point P and sight the station A, B and C and plot the rays Aa, Bb, and Cc. The rays form small triangle which is called triangle of error. Another point P1 is chosen to reduce the error and sight the point A from P1 similarly to B and C. which will give another triangle of error. Repeat this procedure until error becomes zero.



### Analytical Methods

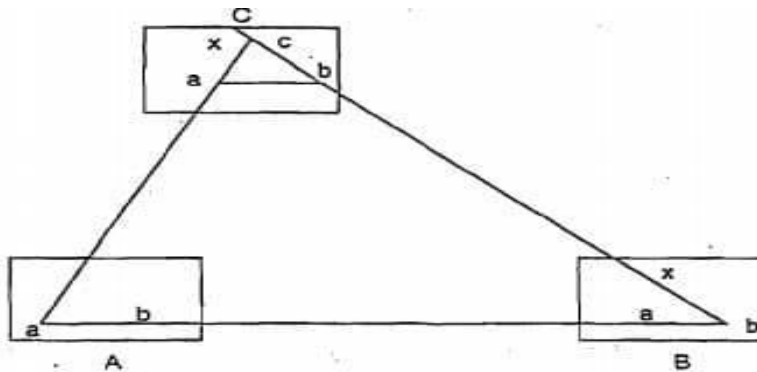
There are many analytical methods are developed in three-point problem condition. In this method, from station P A, B and C are sighted and note the values of angles and lengths. From these values determine the position of unknown points by using analytical formulae.

**Graphical Method:** In graphical method also, angles and lengths are determined and represented it on a graph and determines the location of plane table.

**The Two-Point Problem:** In the two-point problem, two points are sighted from other point corresponding to the points given in plane table sheet. Here two cases are to be discussed.

**Case 1: when the points can be occupied by the plane table**

As shown in fig. A and B are the two points corresponding to the points a and b. Now, plane table is located at B and oriented by sighting A. sight C from B and bx is plotted on the sheet. Then shift the plane table to C, oriented by backsighting B along xb. Then alidade is placed over a and sight station A, then line Aa cuts the line bx at somewhere which is located as point c at station C.



**Case2: When the plane table cannot occupy the controlling stations**

In this case, an auxiliary point D is considered nearer to C. Locate the plane table at D according to the line ab parallel to AB. Then sight the station A and B corresponding to a and b. the rays drawn are intersected at some point which is marked as d. then sight towards C by placing alidade at d. mark the distance Dc as c1. Shift the table to C and backsight to D with reference to c1.

Then sight A corresponding to a, the ray drawn is intersects the previously drawn ray from D in c2. From c2 sight B draw a ray which intersects db and marked the intersection as b1. The table is oriented till ab comes in line with P. From P sight and draw rays Aa and Ba. The intersection of these two rays will give the Location of Point

## 2.7 Advantages and Disadvantages of Plane Table Surveying:

Following are some of the significant advantages and disadvantages of plane table surveying.

### Advantages of Plane Table Survey:

- (1) Map of the area is plotted in the field, i.e., both the field work and the plotting are done simultaneously.
- (2) Field notes of the measurements are not required, and thus the errors in booking are eliminated.
- (3) The correctness of plotted work can be checked by check observations in the field.
- (4) Office work is only finishing up of the drawing.
- (5) Direct measurements of lines and angles are avoided as they are obtained graphically.
- (6) Errors due to extended angular observations with angular instruments and incorrect plotting with bad protractors are avoided.
- (7) This is suitable in a magnetic area where you can't rely on the compass survey.
- (8) More work will be done in less time and labor.
- (9) It is less costly than a theodolite survey.
- (10) It is most suitable for preparing small-scale maps.
- (11) Contours and irregular objects may be represented accurately.
- (12) The reduced levels of points other than the station points of known elevations may be found out with the help of a tangent clinometer.
- (13) The survey can be completed very rapidly.
- (14) Much skill is not required to prepare a map.
- (15) The danger of omitting the necessary measurement is eliminated as the survey is plotted in the field.

### Disadvantages of plane table survey:

- (1) Plane tabling is not suitable for work in wet climates, in places where high winds predominate, and in wooded country.
- (2) If the area to be surveyed is large, frequent changes in the size of drawing sheets are required.
- (3) Due to changes in temperature, the table is liable to warp.
- (4) If the sun is bright, plotting may be difficult due to the strain on the eyes.
- (5) It is not very accurate for large-scale surveys as compared to compass and theodolite surveys.
- (6) The instruments and its accessories are heavy and cumbersome, and they are likely to be lost.
- (7) Since the field notes are not maintained, it is inconvenient to calculate the quantities or re-plot the survey to a different scale if required.
- (8) Although the plane table is advantageous in open country, it is inferior to the compass in the thickly wooded lands.
- (9) The plane tabling is not intended for accurate work.



## 2.8 Errors in Plane Table Surveying

The errors in plane table surveying are of three types:

1. Instrumental errors
2. Errors in plotting
3. Errors due to manipulation and sighting

### 1. Instrumental Errors

Instrumental errors are the primary source of errors in plane table surveying which can occur in the following ways:

- Errors will occur if the top surface of the plane table is not flat or contains undulations.
- The fittings of the tripod and plane table should be tightly fastened. Loose fittings can make the plane table unstable and cause errors while drawing.
- The magnetic compass used in plane table surveying should represent accurate direction otherwise an error may occur due to the wrong orientation of plane table.
- When the beveled edge or fiducial edge of the alidade is not straight or curved, an error occurs in the drawing.
- Both sight vane and object vane of alidade should be perpendicular to the base of an alidade- if not, there will be an error in sighting.
- Faulty Spirit level or level tube may not keep the plane table in horizontal position, therefore an error may occur.



Fig 1 : Plane Table, Alidade and Bubble

**2. Errors in Plotting:** Errors may occur during plotting as well and they could be due to:

- Use of poor quality drawing sheet may affect the scale of the drawing. It is due to the expansion or contraction of drawing paper against temperature changes. Well-seasoned drawing sheet will not expand or contract due to weather fluctuations.
- The pencil used for plotting should contain thin and sharp nose. Usage of a thick pencil may alter the scale of drawing especially in the case of very small scale drawings.



Fig 2 : Plotting

### 3. Errors of Manipulation and Sighting

Errors of manipulation and sighting come under personal errors or man-made errors.

They may occur due to any of the following cases :

- The plane table should be clamped to a tripod in such a way that it should not move while drawing or changing location. Improper clamping causes errors.
- The drawing sheet of the plane table should be firmly fixed to the plane table using thumb screws or clips. If it is unstable, plotting errors will occur.
- The sight vane should always be in a vertical position while sighting objects. To make the sight vane vertical, the plane should be levelled accurately. Improper levelling may cause inclination of sight vane with vertical axis resulting errors in plane table surveying.
- The centering error occurs when the plane table is not exactly over the ground point. So, centering should be done carefully using plumbing fork.
- When there are multiple instrument stations, the orientation of the plane table is compulsory. Improper orientation leads to errors in the angular position of points.
- Improper sighting through vanes causes errors in direction of the object. Hence, the sighting should be done in such a way that the object should be bisected exactly in the middle.
- Improperly fixed tripod can also cause plotting errors. It should be firmly fixed to the ground.