UNIT-5

LECTURE 21

Traversing and plotting with the compass survey:

Traversing with the compass involves taking the bearing along a series of connecting straight lines and in the same time measuring the distances with the tape. The compass is read at each point and a back bearing is equally taken to serve as a check. This continues until the traverse closes.

Choosing a suitable scale, the traverse is then plotted taking into consideration the general shape of the area.

Observing Bearing of Line

- Consider a line AB of which the magnetic bearing is to be taken.
- By fixing the ranging rod at station B we get the magnetic bearing of needle wrt north pole.
- The enlarged portion gives actual pattern of graduations marked on ring.

Designation of bearing

- The bearing are designated in the following two system:-
- 1) Whole Circle Bearing System.(W.C.B)
- 2) Quadrantal Bearing System.(Q.B)

Whole circle bearing system (W.C.B.)

- The bearing of a line measured with respect to magnetic meridian in clockwise direction is called magnetic bearing and its value varies between 0^{O} to 360^{O}.
- The quadrant start from north and progress in a clockwise direction as the first quadrant is 0^{O} to 90^{O} in clockwise direction , 2^{nd} 90^{O} to 180^{O} , 3^{rd} 180^{O} to 270^{O}, and up to 360^{O} is 4^{th} one.

Quadrantal bearing system(Q.B.)

- In this system, the bearing of survey lines are measured wrt to north line or south line whichever is the nearest to the given survey line and either in clockwise direction or in anti clockwise direction.

Reduced bearing (R.B)

- When the whole circle bearing is converted into Quadrantal bearing , it is termed as “REDUCED BEARING”.
- Thus , the reduced bearing is similar to the Quadrantal bearing.

- Its values lies between 0^{O} to 90^{O}, but the quadrant should be mentioned for proper designation.

The following table should be remembered for conversion of WCB to RB.

W.C.B OF ANY LINE	QUADRANT IN WHICH IT LIES	RULES FOR CONVERSION	QUADRANT
0 TO 90	I	RB=WCB	N-E
90 TO 180	II	RB=180-WCB	S-E
180 TO 270	III	RB =WCB-180^{O}	S-W
270 TO 360	IV	RB=360^{O} - WCB	N-W

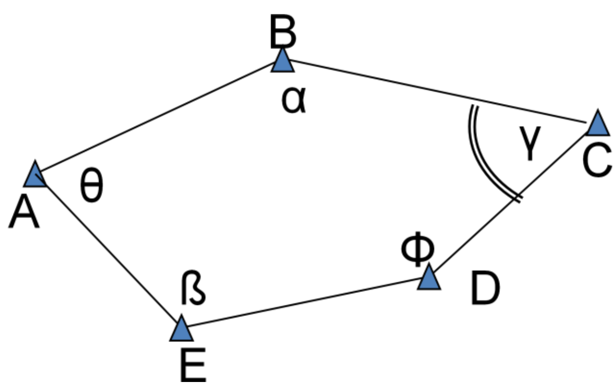
LECTURE 22

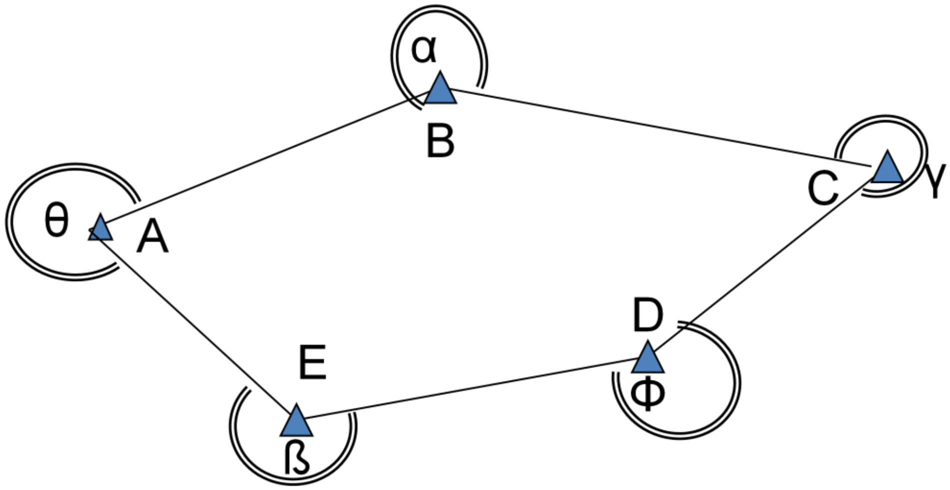
Error in compass survey (Local attraction & observational error):

- Local attraction is the influence that prevents magnetic needle pointing to magnetic north pole
- Unavoidable substance that affect are
  - Magnetic ore
  - Underground iron pipes
  - High voltage transmission line
  - Electric pole etc.
- Influence caused by avoidable magnetic substance doesn't come under local attraction such as instrument, watch wrist, key etc
- Detection of Local attraction
  - By observing the both bearings of line (F.B. & B.B.) and noting the difference (180^0 in case of W.C.B. & equal magnitude in case of R.B.)
  - We confirm the local attraction only if the difference is not due to observational errors.
- If detected, that has to be eliminated
- Two methods of elimination
  - First method
  - Second method
- First method
  - Difference of B.B. & F.B. of each lines of traverse is checked to note if they differ by correctly or not.
  - The one having correct difference means that bearing measured in those stations are free from local attraction
  - Correction is accordingly applied to rest of station.
  - If none of the lines have correct difference between F.B. & B.B., the one with minimum error is balanced and repeat the similar procedure.
  - Diagram is good friend again to solve the numerical problem.

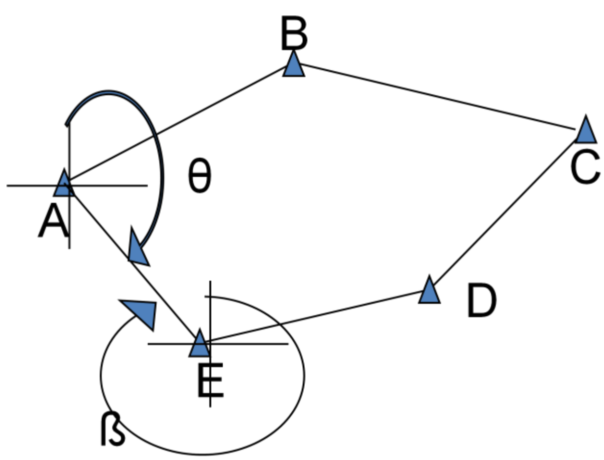
LECTURE 23

- Second method
  - Based on the fact that the interior angle measured on the affected station is right.
  - All the interior angles are measured
  - Check of interior angle – sum of interior angles = (2n-4) x right angle, where n is number of traverse side
  - Errors are distributed and bearing of lines are calculated with the corrected angles from the lines with unaffected station.
- Checks in closed Traverse
  - Errors in traverse is contributed by both angle and distance measurement
  - Checks are available for angle measurement but
  - There is no check for distance measurement
  - For precise survey, distance is measured twice, reverse direction second time
- Checks for angular error are available
  - Interior angle, sum of interior angles = (2n-4) x right angle, where n is number of traverse side
  - Exterior angle, sum of exterior angles = (2n+4) x right angle, where n is number of traverse side





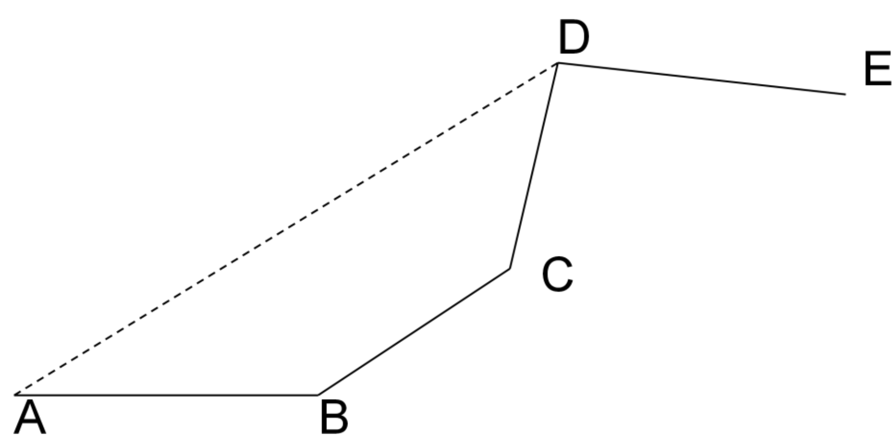
- Deflection angle – algebraic sum of the deflection angle should be 0^0 or 360^0.
- Bearing – The fore bearing of the last line should be equal to its back bearing ± 180^0 measured at the initial station.

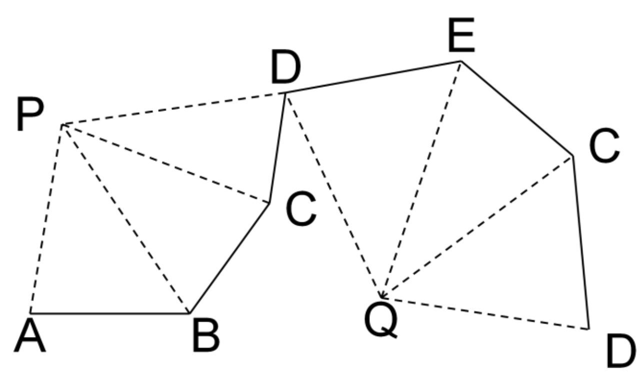


ß should be = $\theta + 180^0$

LECTURE 24

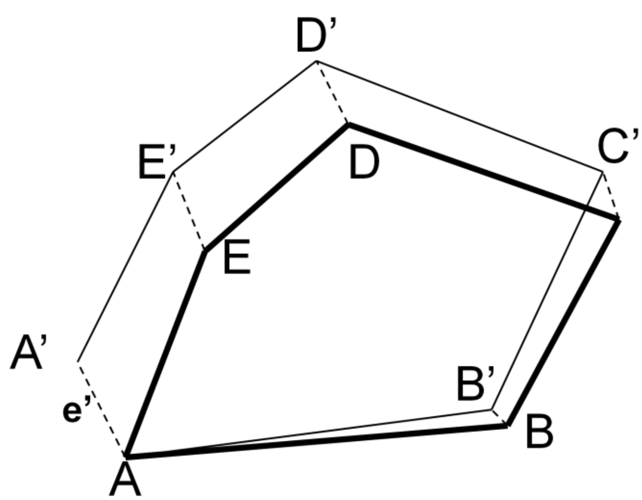
- Checks in open traverse
  - No direct check of angular measurement is available
  - Indirect checks
    - Measure the bearing of line AD from A and bearing of DA from D
    - Take the bearing to prominent points P & Q from consecutive station and check in plotting.

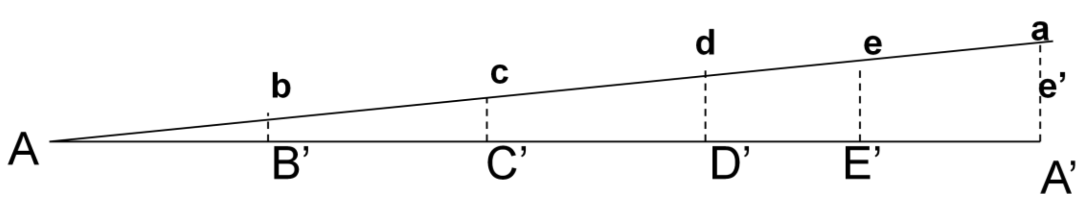




- Methods
    - Compass rule (Bowditch)
        - When both angle and distance are measured with same precision
    - Transit rule
        - When angle are measured precisely than the length
    - Graphical method

- Graphical rule
    - Used for rough survey
    - Graphical version of bowditch rule without numerical computation
    - Geometric closure should be satisfied before this.





LECTURE 25

PLANE TABLE SURVEYING

Principle :-

The principle of plane tabling is parallelism, meaning that the rays drawn from stations to objects on the paper are parallel to the lines from the stations to the objects on the ground. The relative positions of the objects on the ground are represented by their plotted positions on the paper and lie on the respective rays. The table is always placed at each of the successive stations parallel to the position it occupied at the starting station. Plane tabling is a graphical method of surveying there the field work and plotting are done simultaneously and such survey does not involve the use of a field book.

Plane table survey is mainly suitable for filling interior details when traversing is done by theodolite sometimes traversing by plane table may also be done. But this survey is recommended for the work where great accuracy is not required. As the fitting and fixing arrangement of this instrument is not perfect, most accurate work cannot be expected.

Accessories of Plane Table :-

1. The Plane Table :-

The plane table is a drawing board of size 750 mm x 600 mm made of well seasoned wood like teak, pine etc. The top surface of the table is well leveled. The bottom surface consists of a threaded circular plate for fixing the table on the tripod stand by a wing nut.

The plane table is meant for fixing a drawing sheet over it. The positions of the objects are located on this sheet by drawing rays and plotting to any suitable scale.

2. The Alidade :-

There are two types of alidade.

(i) Plain

(ii) Telescopic.

(a) Plain Alidade :-

The plain alidade consists of a metal or wooden ruler of length about 50 cm. One of its edge is beveled and is known as the fiducial edge. It consists of two vanes at both ends which are hinged with the ruler. One is known as the ‘object vane’ and carries a horse hair, the other is called the ‘sight vane’ and is provided with a narrow slit.

(b) Telescopic Alidade :-

The telescopic alidade consists of a telescope meant for inclined sight or sighting distant objects clearly. This alidade has no vanes at the ends, but is provided with fiducial edge. The function of the alidade is to sight objects. The rays should be drawn along the fiducial ends.

3. The Spirit Level :-

The spirit level is a small metal tube containing a small bubble of spirit. The bubble is visible on the top along a graduated glass tube. The spirit level is meant for leveling the plane table.

4. The Compass :-

There are two kinds of compass.

(a) the trough compass and

(b) the circular box compass.

(a) The Trough Compass :-

The trough compass is a rectangular box made of non-magnetic metal containing a magnetic needle pivoted at the centre. This compass consists of a ‘D’ mark at both ends to locate the N-S direction.

(b) The Circular Box Compass :-

It carries a pivoted magnetic needle at the centre. The circular box is fitted on a square base plate sometimes two bubble tubes are fixed at right angles to each other on the base plate. The compass is meant for marking the north direction of the map.

5. U-fork or plumbing fork with plumb bob :-

The U-fork is a metal strip bent in the shape of a ‘U’ (hair pin) having equal arm lengths, the top arm is pointed and the bottom arm carried a hook for suspending a plumb bob. This is meant for centering the table over a station.

LECTURE 26

Methods of Plane Table Surveying

Four classes of plane tabling surveys are recognized:

Radiation method;

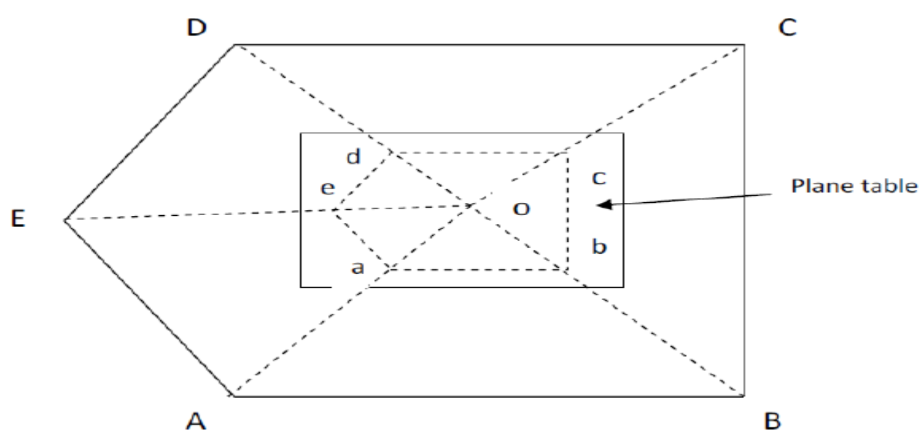
Intersection method;

Traversing method,

Resection method.

Radiation Method

Here, the plane table is set up at one station which allows the other station to be accessed. The points to be plotted are then located by radiating rays from the plane table station to the points. After reducing the individual ground distances on the appropriate scale, the survey is then plotted. This method is suitable for small area surveys. It is rarely used to survey a complete project but is used in combination with other methods for filing in details within a chain length.



Plane Tabling using Radiation Method

The following steps are taken:

1. Select a point O such that all the points are visible

2. Set up and level the instrument at O

3. From O align the Alidade and draw radial lines towards. The stations A, B, C, D and E.

4. Measure the distances OA, OB, OC, OD and OE: scale and draw Oa, Ob, Oc, Od and Oe on the paper.

5. Join the point a, b, c, d, and e to give the outline of the survey.

LECTURE 27

Intersection Method

In this method, two instrument stations are used with the distance between them called based line serving as the base to measure and plot the other locations:

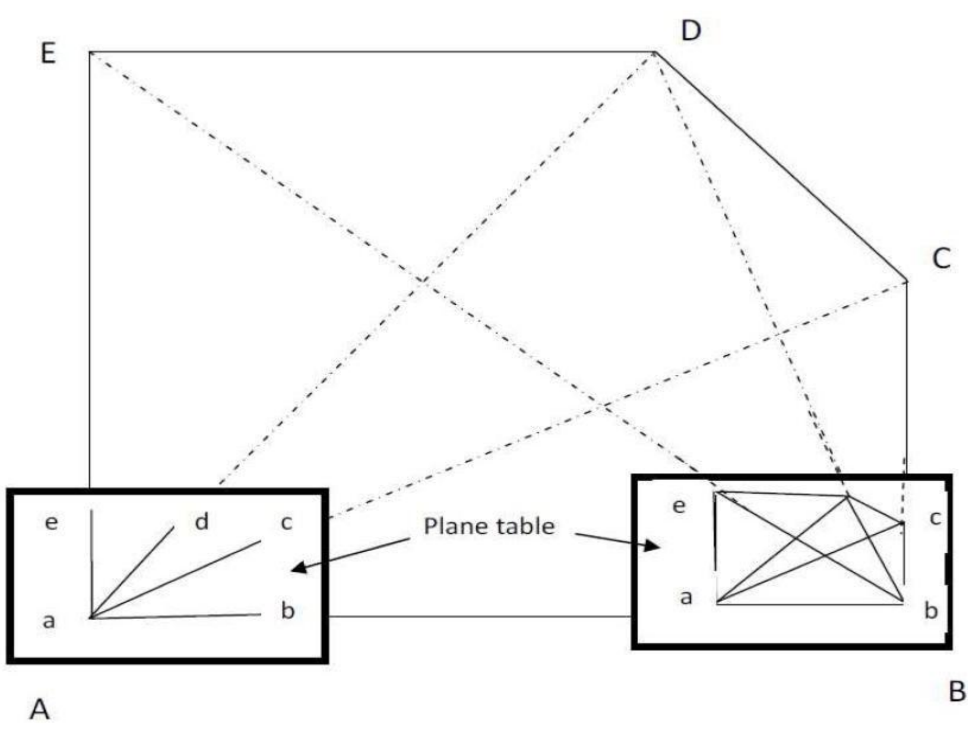
1. 2 points A and B are selected from which the rest of the stations can be seen.

2. Set up and level the plane table at A and mark it as a in the paper to coincide with A on the ground.

3. Sight B, C, D and E with the Alidade from a and draw rays which forwards them.

4. Measure AB, AC, AD and AE and using appropriate scale draw the corresponding paper distance.

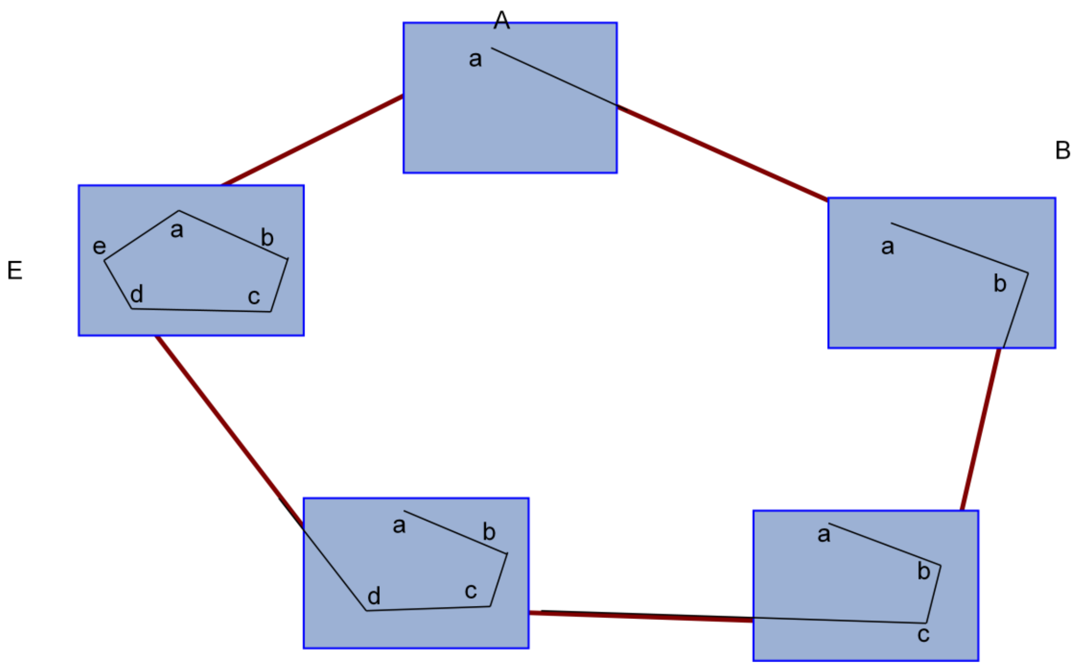
5. Remove the equipment from A to B and repeat the procedure using B as the measuring station.



Plane Tabling using Intersection Method

TRAVERSING METHOD

This is similar to that of Compass Survey or Transit Traversing. It is used for running survey lines between stations, which have been previously fixed by other methods of survey, to locate the topographic details. It is also suitable for the survey of roads, rivers, etc.



Plane Tabling using Traversing Method

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LECTURE 28

Resection :-

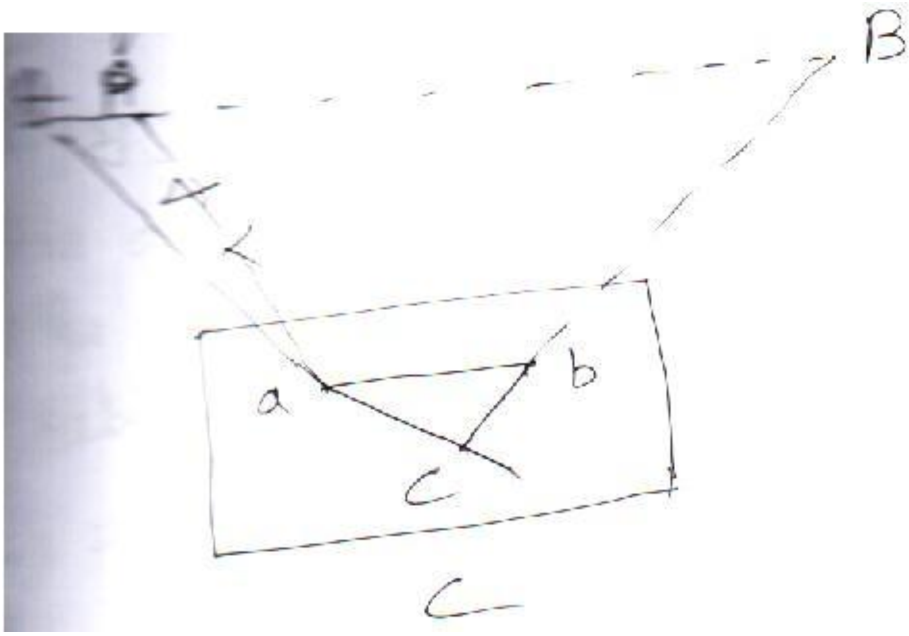
Resection is the process of determining the plotted position of the station occupied by the plane table, by means of sights taken towards known points, locations of which have been plotted.

The method consists in drawing two rays to the two points of known location on the plan after the table has been oriented. The rays drawn from the un-plotted location of the station to the points of known location are called resectors, the intersection of which gives the required location of the instrument stations. If the table is not correctly oriented at the station to be located on the map, the intersection of the two resectors will not give the correct location of the station. The problem, therefore, lies in orienting table at the stations and can be solved by the following four methods of orientation.

(i) Resection after orientation by compass.
(ii) Resection after orientation by back sighting.
(iii) Resection after orientation by three point problem.
(iv) Resection after orientation by two-point problem.

(i) Resection after orientation by compass :-

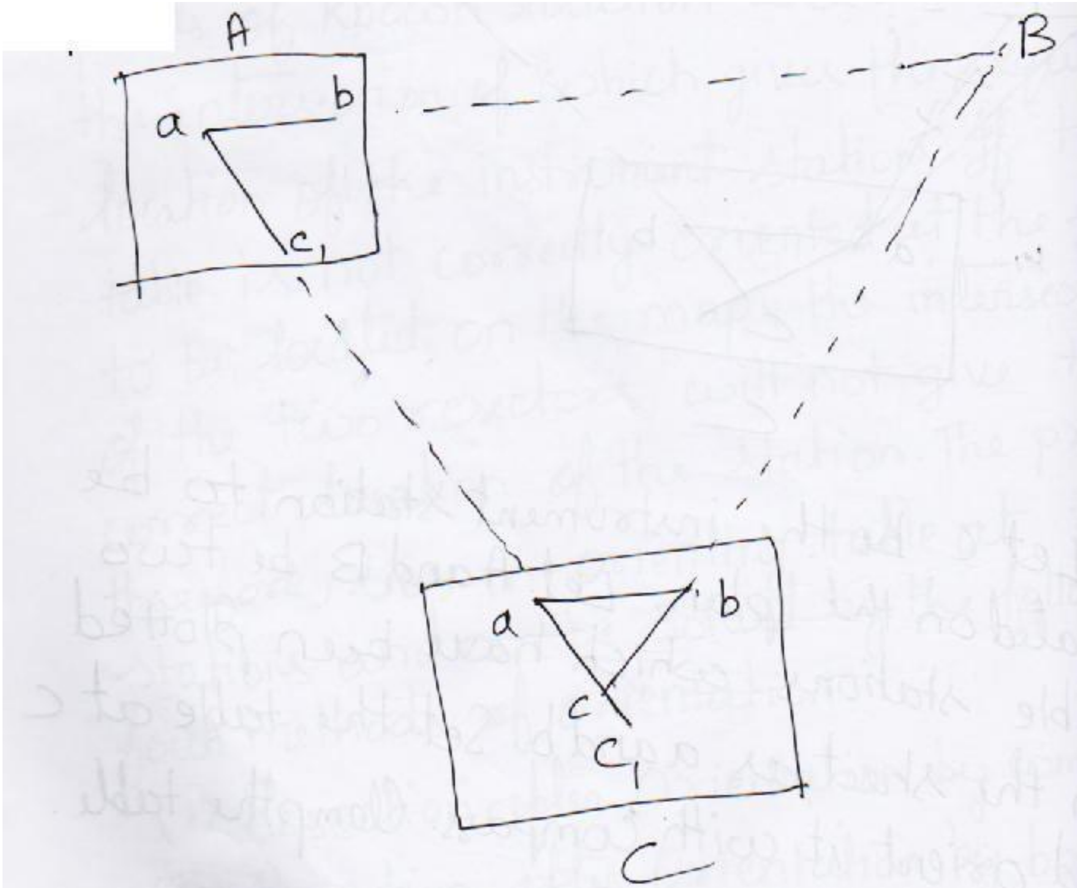
The method is utilized only for small scale or rough mapping for which the relatively large errors due to orienting with the compass needle would not impair the usefulness of the map. The method is as follows :



1. Let 'C' be the instrument station to be located on the plan. Let 'A' and 'B' be two visible stations which have been plotted on the sheet as 'a' and 'b'. set the table at 'c' and orient it with compass. Clamp the table.
2. Pivoting the alidade about 'a', draw a resector (ray) towards 'A'; similarly, sight 'B' from 'b' and draw a resector. The intersection of the two resectors will give 'C', the required point.

(ii) Resection after orientation by back sighting :-

If the table can be oriented by back sighting along a previously plotted back sight line, the station can be located by the intersection of the back sight line and the resector drawn through another known point. The method is as follows :



1. Let ‘C’ be the station to be located on the plan and ‘A’ and ‘B’ be two visible points which have been plotted on the sheet as ‘a’ and ‘b’. Set the table at ‘A’ and orient it by back sighting ‘B’ along ‘ab’.
2. Pivoting the alidade at ‘a’. sight ‘C’ and draw a ray. Estimate roughly the position of ‘C’ on this ray as C_1.
3. Shift the table to ‘C’ and centre it approximately with respect to C_1. Keep the alidade on the line c_1a and orient the table by back sight to ‘A’, Clamp the table which has been oriented.
4. Pivoting the alidade about ‘b’, sight ‘B’ and draw the resector ‘bB’ to intersect the ray ‘c_1a’ in ‘C’. Thus, ‘C’ is the location of the instrument station.

The Three-Point Problem :

Statement :-

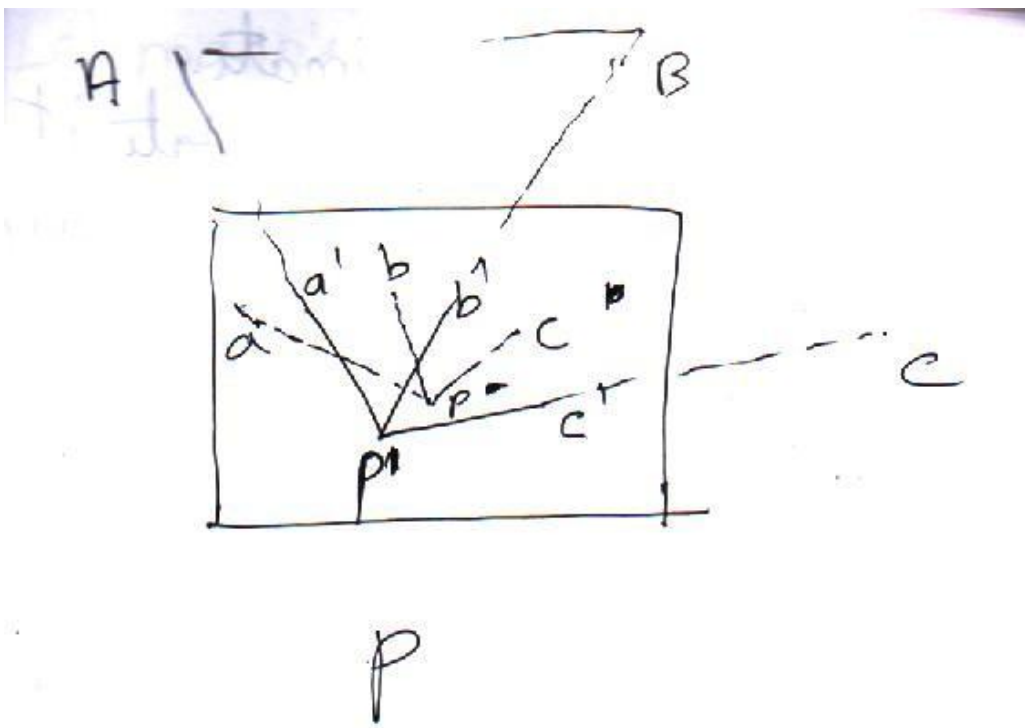
Location of the position, on the plan of the station occupied by the plane table by means of observations to three well-defined points whose positions have been previously plotted on the plan.

The following are some of the important methods available for the solution of the problem.

(a) Mechanical Method (Tracing Paper Method)
(b) Graphical Method
(c) Lehmann's Method (Trial and Error Method)

(a) Mechanical Method (Tracing Paper method)

The method involves the use of a tracing paper and is, therefore also known as tracing paper method.



Procedure :

Let A, B, C be the known points and a, b, c be their plotted positions. Let 'P' be the position of the instrument station to be located on the map.

(1) Set the table on P. Orient the table approximately with eye so that 'ab' is parallel to AB.
(2) Fix a tracing paper on the sheet and mark on it P' as the approximately location of 'P' with the help of plumbing fork.

(3) Pivoting the alidade at ‘P’, sight A, B, C in turn and draw the corresponding lines P’a’, P’b’ and P’c’ on the tracing paper. These lines will not pass through a, b and c as the orientation is approximate.

(4) Loose the tracing paper and rotate it on the drawing paper in such a way that the lines p’a’, p’b’ and p’c’ pass through a, b and c respectively. Transfer p’ on to the sheet and represent it as p. Remove the tracing paper and join pa, pb and pc.

(5) Keep the alidade on pa. The line of sight will not pass through ‘A’ as the orientation has not yet been corrected. To correct the orientation, loose the clamp and rotate the plane table so that the line of sight passes through ‘A’. Clamp the table. The table is thus oriented.

(6) To test the orientation keep the alidade along pb. If the orientation is correct, the line of sight will pass through B. similarly, the line of sight will pass through ‘C’ when the alidade is kept on pc.

Lehmann’s Method :-

This is the easiest and quickest solution. The principles of the method are as follows :

(a) When the board is properly oriented and the alidade sighted to each control signals A, B and C, rays drawn from their respective signals will interest at a unique point.

(b) When rays are drawn from control signals, the angles of their intersections are true angles whether or not the board is properly oriented.

Procedure :-

1. Set the table over new station p and approximately orient it.
2. With alidade on a sight A, similarly sight B and C. The three rays Aa, Bb and Cc will meet at a point if the orientation is correct. Usually, however, they will not meet but will form a small triangle known as the triangle of error.
3. To reduce the triangle of error to zero, another point ‘p’ is chosen as per Lehmann’s rule.
4. Keep the alidade along p’a and rotate the table to sight A. Clamp the table. This will give next approximate orientation (but more accurate than the previous one).

Then sight 'B' with alidade at b and 'C' with alidade at c. The rays will again form a triangle of error but much smaller.

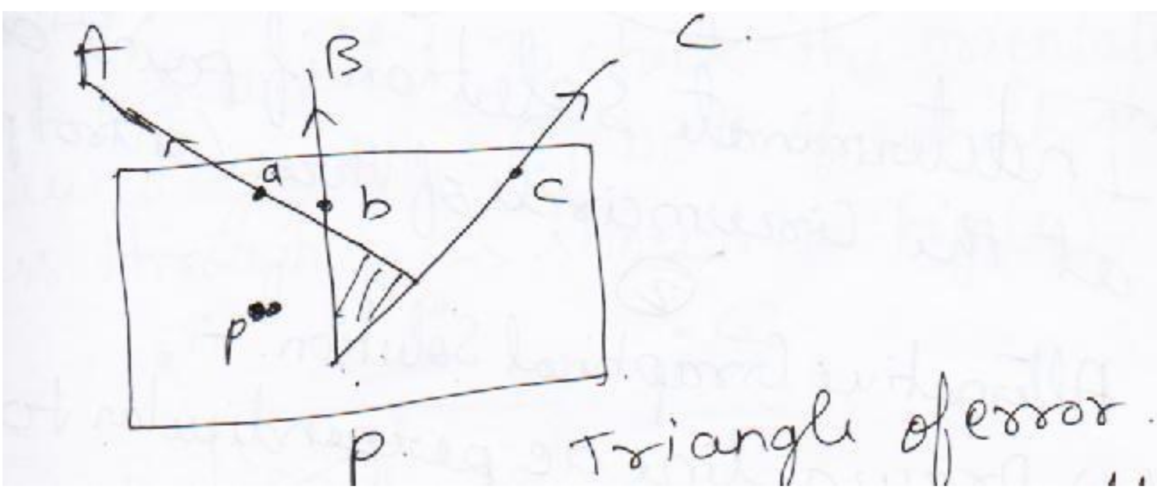
5. The method has to be repeated till the triangle of error reduces to zero.

Lehmann's Rules :-

There are three rules to help in proper choice of the point p'.

1. If the plane table is set up in the triangle formed by the three points (i.e. p lies within the triangle ABC) then the position of the instrument on the plan will be inside the triangle of error, if not it will be outside.
2. The point P' should be so chosen that its distance from the rays Aa, Bb and Cc is proportional to the distance of p from A, B and C respectively. Since the rotation of the table must have the same effect on each ray.
3. The point p' should be so chosen that it lies either to the right of all three rays or to the left of all three rays, since the table is rotated in one direction to locate P.

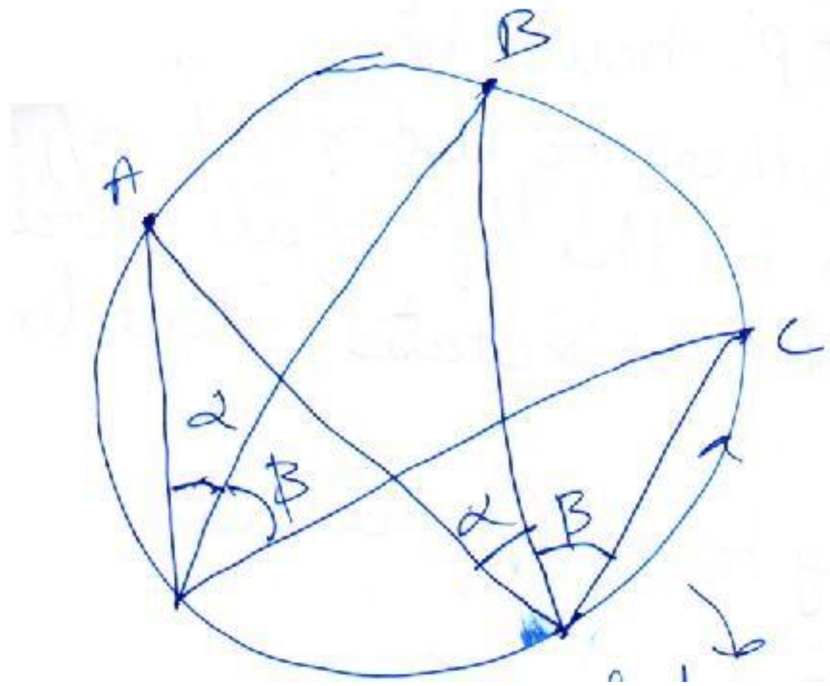
Referring to the figure below :



By rule 1 p is outside the small triangle as p is outside the triangle ABC.

By rule 2, using the proportions for the perpendiculars given by scaling the distances PA, PB and PC, it must be in the left hand sector as shown.

By rule 3, it cannot be in either of the sectors contained by the rays PA, PB and PC.



Indeterminate solution if point occupied at the circum circle of the three control points :-

Alternative Graphical Solution :-

(1) Draw a line 'ae' perpendicular to 'ab' at 'a'. Keep the alidade a long 'ea' and rotate the plane Table till 'A' is bisected. Clamp the table with 'b' as centre, direct the alidade to sight B and draw the ray be to cut 'ae' in 'e' Fig 28.1 (a)

(2) Similarly, draw 'cf' perpendicular to 'bc' at 'c'. Keep the alidade along 'FC' and rotate the plane table till 'c' is bisected clamp the table. With 'b' as centre, direct the alidade to sight 'B' and draw the ray 'bf' to cut 'cf' in F Fig 28.1(b)

(3) Join 'e' and 'F'. Using a set sequre, draw 'bp' perpendicular to 'ef'. Then 'p' represents on the plane the position 'p' of the table on the ground.

(4) To orient the table, keep the alidade along 'pb' rotate the plane table till 'B' is bisected. To check the orientation draw rays aA, cC both of which should pass through 'p' as shown in Fig. 28.1 (c).

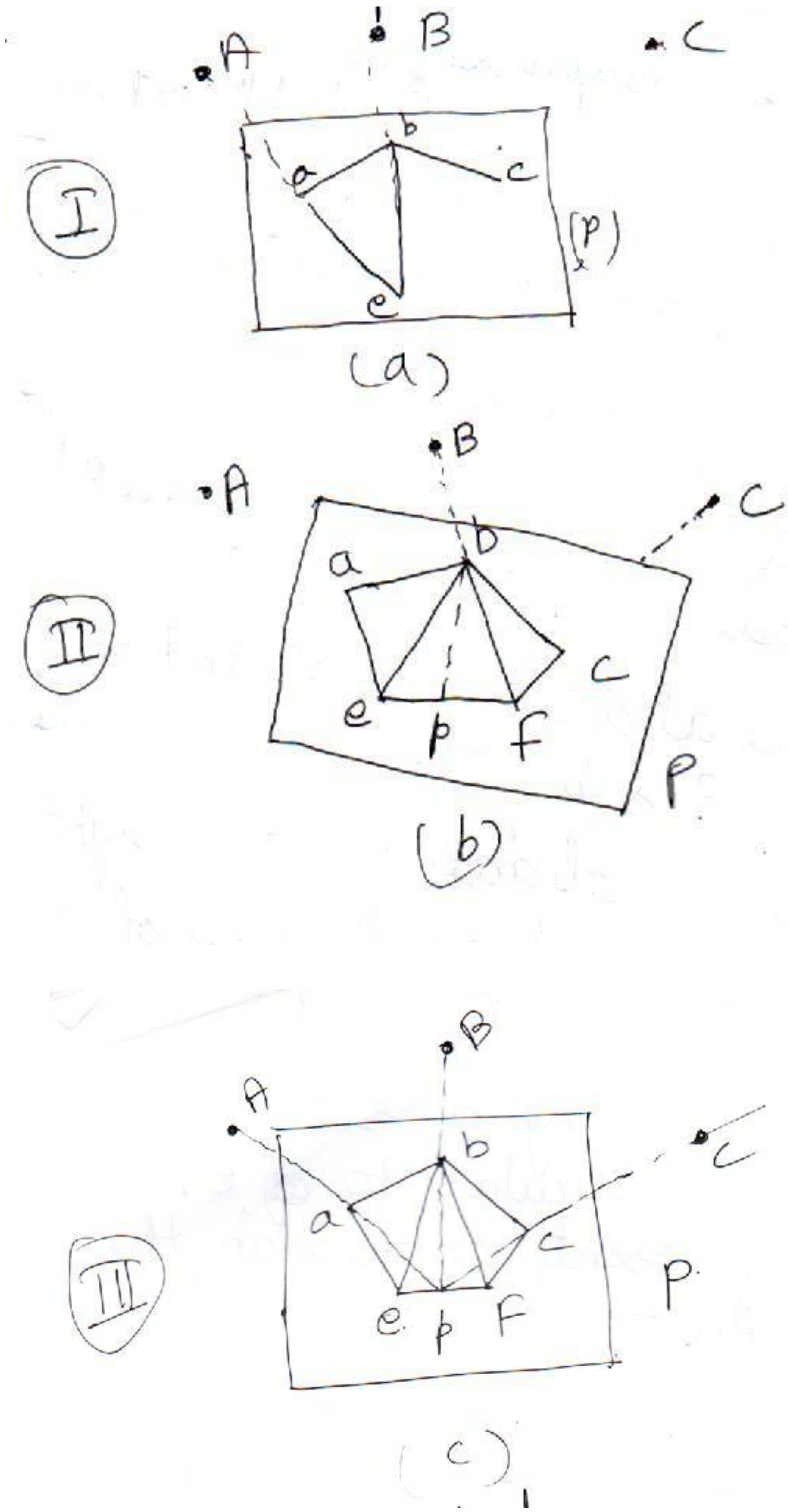


Fig. 28.1

Graphical Method :-

There are several graphical methods available, but the method given by Bessel is more suitable and is described first.

Bessel's Graphical Solution :-

(1) After having set the table at station 'P', keep the alidade on 'ba' and rotate the table so that 'A' is bisected. Clamp the table.

(2) Pivoting the alidade about 'b', sight to 'C' and draw the ray 'xy' along the edge of the alidade. [Fig28.2 (a)]

(3) Keep the alidade along 'ab' and rotate the table till 'B' is bisected clamp the table.

(4) Pivoting the alidade about 'a', sight to 'C'. Draw the ray along the edge of the alidade to interest the ray 'xy' in 'cf'. [Fig 28.2 (b)] Join cc'.

(5) Keep the alidade along c'c and rotate the table till 'C' is bisected. Clamp the table. The table is correctly oriented [Fig 28.2 (c)].

(6) Pivoting the alidade about 'b', sight to 'B'. Draw the ray to intersect cc' in 'p'. Similarly, if alidade is pivoted about 'a' and 'A' is sighted, the ray will pass through 'p' if the work is accurate.

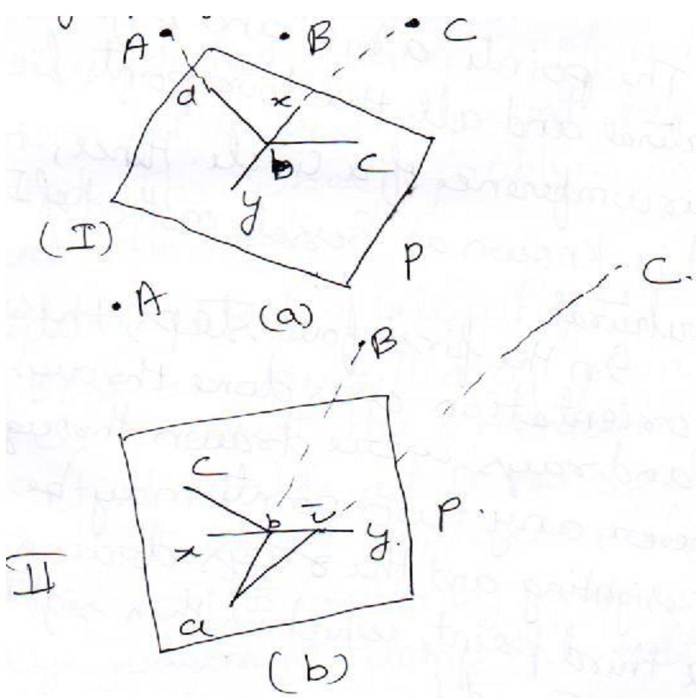


Fig 28.2

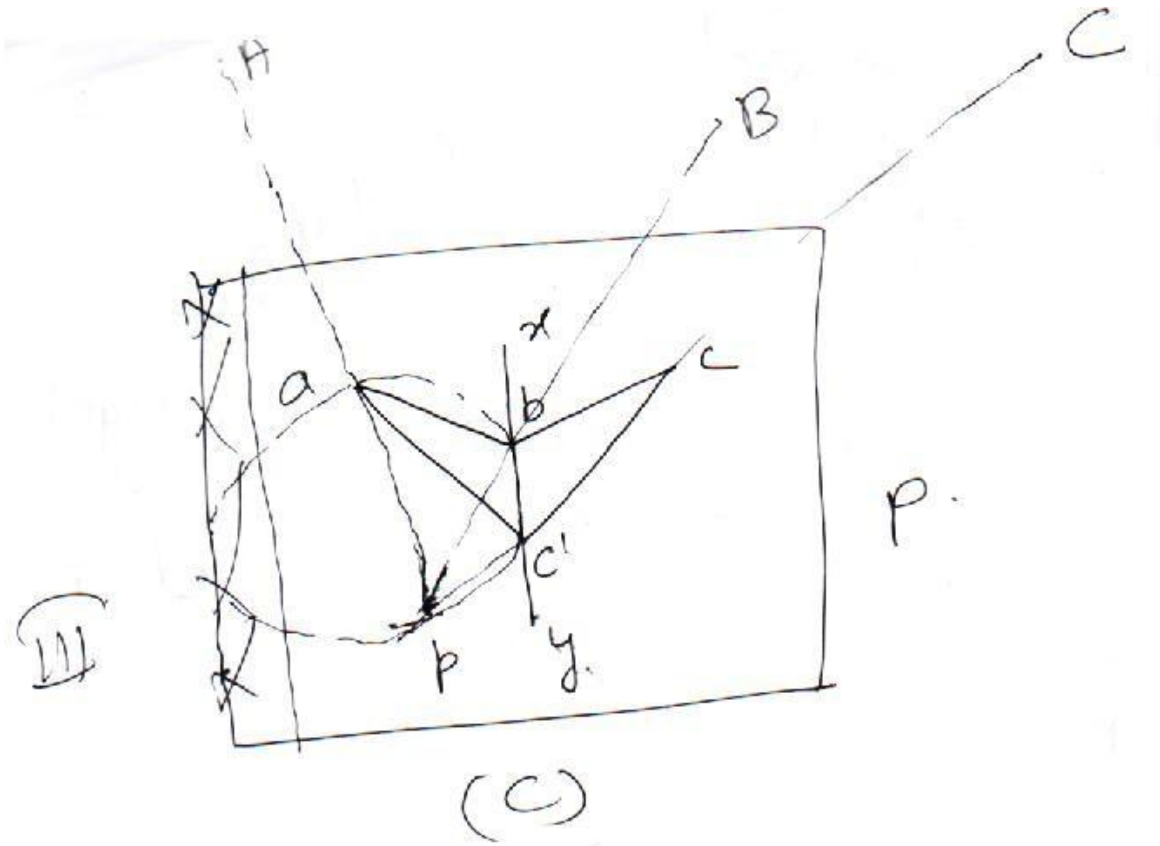


Fig 28.2

The points a, b, c' and 'p' form a quadrilateral and all the four points lie along the circumference of a circle. Hence, this method is known as "Bessel's method of Inscribed Quadrilateral".

In the first four steps, the sightings for orientation was done through 'a' and 'b' and rays were drawn, through 'c'. However, any two points may be used for sighting and the rays drawn towards the third point, which is then sighted in steps 5 and 6.

LECTURE 29

Two Point Problem :-

Statement :-

"Location of the position on the plan of the station occupied by the plane table by means of observation to two well defined points whose positions have been previously plotted on the plan."

Let us take two points 'A' and 'B', the plotted positions of which are known. Let 'C' be the point to be plotted. The whole problem is to orient the table at 'C'.

Procedure : (Refer below Fig 29.)

(1) Choose an auxiliary point 'D' near 'C', to assist the orientation at 'C'. set the table at 'D' in such a way that 'ab' is approximately parallel to 'AB' (either by compass or by eye judgment) clamp the table.

(2) Keep the alidade at 'a' and sight 'A'. Draw the resector. Similarly draw a resector from 'b' and 'B' to intersect the previous one in 'd'. The position of 'd' is thus got, the degree of accuracy of which depends upon the approximation that has been made in keeping 'ab' parallel to 'AB'. Transfer the point 'd' to the ground and drive a peg.

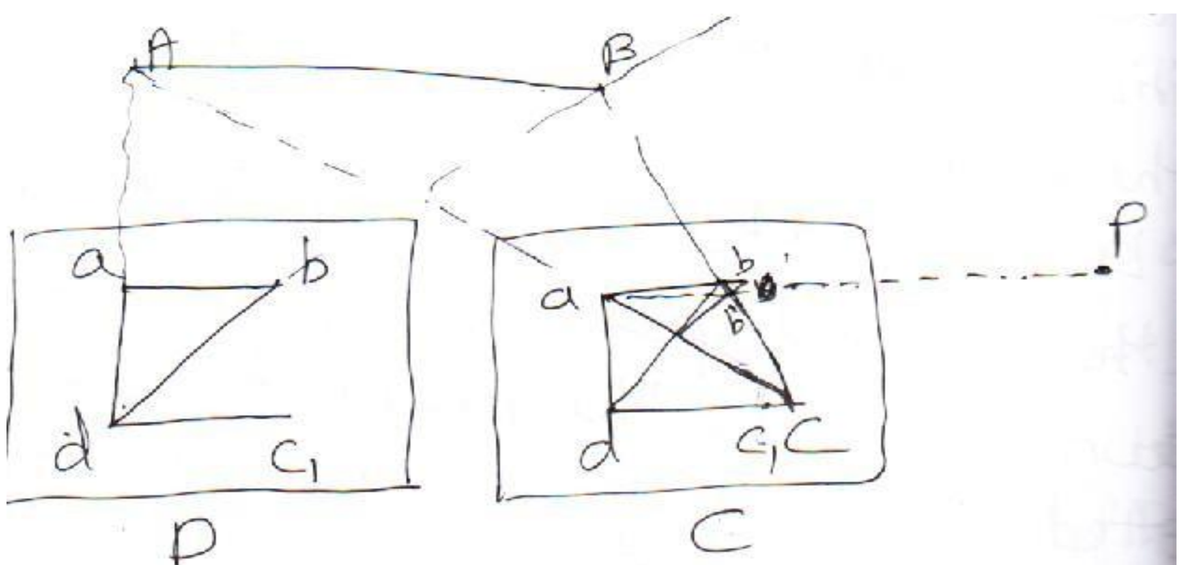


Fig 29 Two point problem

(3) Keep the alidade at 'd' and sight 'C'. Draw the ray. Mark a point c_1 on the ray by estimation to represent the distance 'DC'.

(4) Shift the table to C, orient it (tentatively) by taking backside to 'D' and centre it with reference to c_1. The orientation is, thus the same as it was at 'D'.

(5) Keep the alidade pivoted at 'a' and sight it to 'A'. Draw the ray to interest with the previously drawn ray from 'D' in 'c'. thus, 'c' is the point representing the station C_1 with reference to the approximate orientation made at 'D'.

(6) Pivoting the alidade about 'c', sight 'B'. Draw the ray to intersect with the ray drawn from 'D' to 'B' in b'. Thus b' is the approximate representation of 'B' with respect to the orientation made at 'D'.

(7) The angle between ab and ab' is the error in orientation and must be corrected for. So that 'ab' and ab' may coincide (or may become parallel) keep a pole 'P' in line with ab' and at a great distance. Keeping the alidade along 'ab', rotate the table till 'P' is bisected. Clamp the table. The table is thus correctly oriented.

(8) After having oriented the table as above, draw a resector from 'a' to 'A' and another from 'b' to 'B', the intersection of which will give the position 'C' occupied by the table.

It is to be noted here that unless the point 'P' is chosen infinitely distant, 'ab' and ab' cannot be made parallel since the distance of 'p' from 'C' is limited due to other considerations two-point problem does not give much accurate results. At the same time, more labour is involved because the table is also to be set on one more station to assist the orientation.