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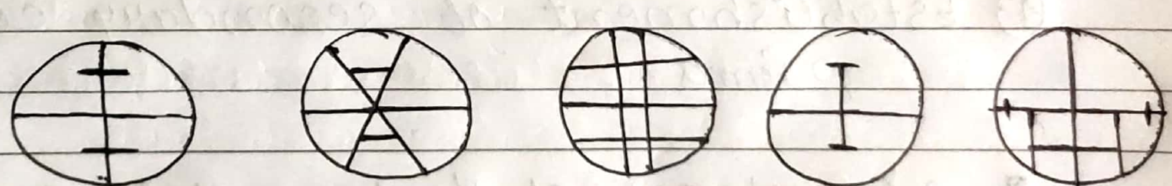
Unit - 3 Tacheometric survey

- Tacheometer is a theodolite arranged with a stadia diaphram having three horizontal lines. The two stadia lines i.e. upper and lower are equidistance from the central horizontal line.
- It is a branch of angular surveying in which the horizontal and vertical distances of points are obtained by optical means. When ground is undulating or inaccessible, direct method i.e. laying of chains or tapes on ground are inconvenient and possibility of errors in reading increases.
- Various patterns of stadia diaphram are upper stadia diaphram and lower stadia diaphram.



(Stadia wires)

Stadia diaphragm consists of one stadia hair above the other equal distance below the horizontal cross hair, the stadia hairs being mounted in the ring and on the same vertical plane as the horizontal and vertical cross hairs.

- Telescope
  - External - focusing telescope
  - Internal - focusing telescope

- External - focusing anallatic telescope.
- Objectives

Tacheometry is the preparation of contour maps or plans requiring both the horizontal as well as vertical control. Also, on surveys of higher accuracy, it provides a check on distances measured with the tape.

- Uses :-

① It is used for preparation of topographic map where both horizontal and vertical distances are required to be measured.
② survey work in difficult terrain where direct methods of measurements are inconvenient.
③ Reconnaissance survey for highways and railways etc.
④ Establishment of secondary control points.

- Advantages of Tacheometric surveying

① Tacheometry can be used as a check where the distances and also the levels have already been measured with other methods like chain, tape, dumpy level etc.
② Tacheometry is used for filling in the details of a traverse.
③ Tacheometry is very useful for rough terrains where direct methods of measurements are difficult.

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(4) For survey of water bodies like the rivers, wet lands, oceans etc. i.e, in hydrographic surveying, tacheometry is a very very suitable method.

(5) This method is suitable for preparation of topographic maps wherein both the horizontal distances and elevations of the points are required.

(6) Because the tacheometric method is quick to perform and is thus it saves time and resources and very suitable for reconnaissance survey.

- Limitations

(1) The staff stations must be clearly visible from the tacheometric station.

(2) Staff man should be able to reach at the point whose elevation is required to be determined.

- Disadvantages

(1) The method is slow

(2) It is very difficult to measure the stadia interval accurately.

(3) computations are tedious as the factor 'm' comes in the denominator.

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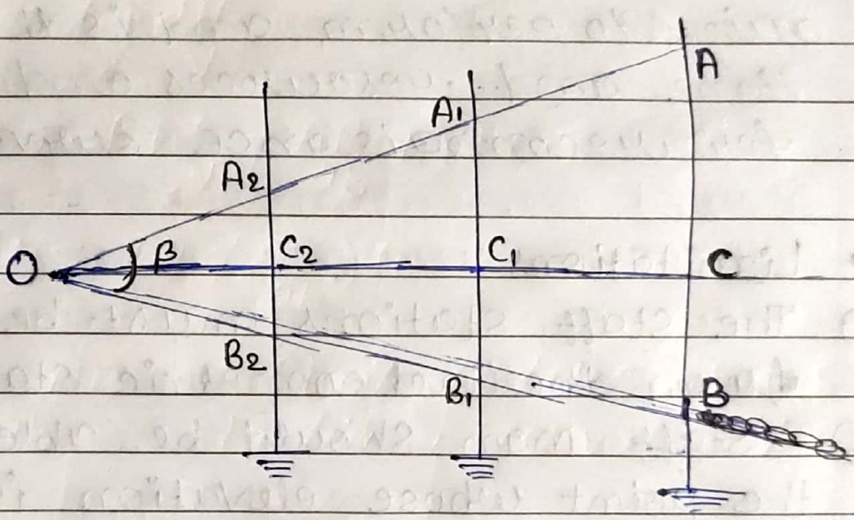
- **principle of Tacheometry**

The principle of tacheometer is based on a property of Isosceles triangles, where the ratio of distance of the base from apex and length of the base is always constant.

Two rays OA and OB be equally inclined to central ray OC. Let A_2B_2, A_1B_1 and AB be the staff intercepts.



From figure, we can write,

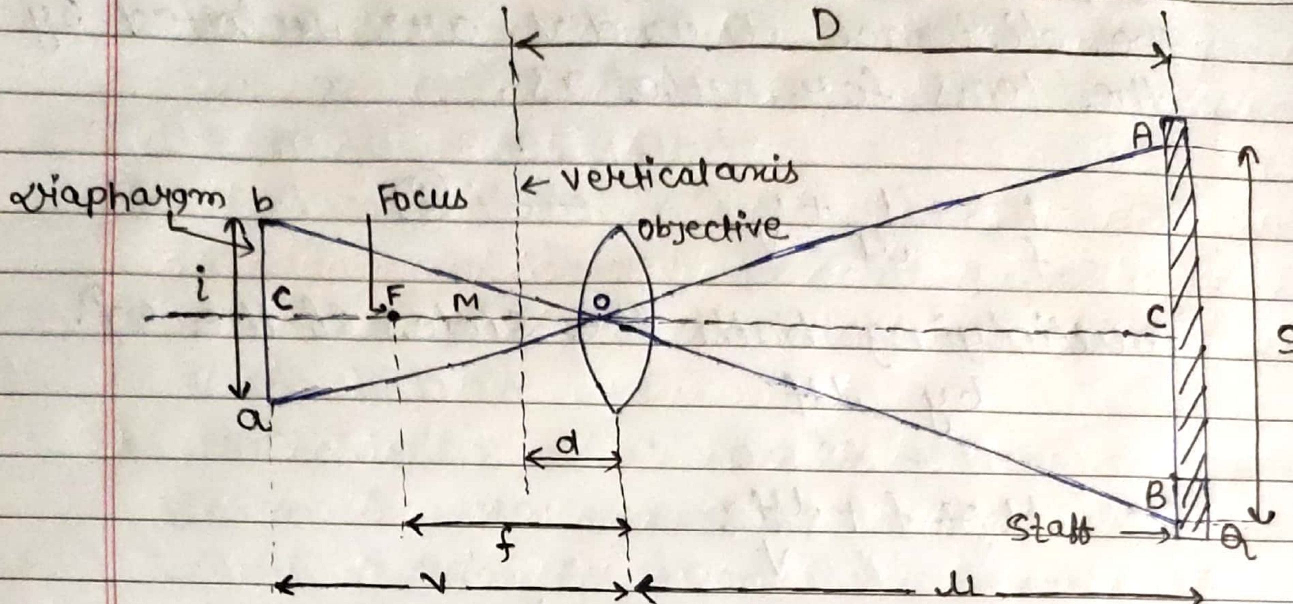
$$\frac{OC_2}{A_2B_2} = \frac{OC_1}{A_1B_1} = \frac{OC}{AB} = \frac{f}{i} \text{ (constant)}$$

where $\frac{f}{i}$ is multiplying constant.

- **Determination of tacheometric constants (Theory of Stadia Tacheometry)**

↳ Let there be an external focusing telescope with horizontal axis also the staff is held vertical at station Q.

Let staff intercept = AB = S



(Stadia method of Tacheometry)

Thus light rays coming from A and B i.e. the rays AO and BO meet at objective center O. This objective forms an inverted image ba of AB.

Now, in ΔAOB and ΔaOb

$\angle AOB = \angle aOb$

(vertically opposite angles)

$\angle abO = \angle ABO$

Thus, $\Delta AOB \sim \Delta aOb$

So, $\frac{AB}{ab} = \frac{OC}{Oc} = \frac{u}{v}$

$$u = \left(\frac{AB}{ab}\right) v \quad \text{——— (1)}$$

Here, ab = Stadia interval

u = Horizontal distance of staff from optical center of objective lens

v = Horizontal distance of cross hairs from optical center of objective lens.

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If f is the focal length of objective (OF) then the distance u and v are related by the lens formula as,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{—— (2)}$$

multiplying both the sides of the eq^n. by uf

$$u = f + \frac{uf}{v}$$

$$u = f + \frac{f}{v}\left(\frac{AB}{ab}v\right)$$

$$u = f + \left(\frac{AB}{ab}\right)f$$

Now, AB = Staff intercept = s
ab = stadia interval = i

$$u = f + \left(\frac{f}{i}\right)s \quad \text{—— (3)}$$

If d is the horizontal distance between vertical axis of the instrument from the optical center O of objective then the horizontal distance (D) is equal to,

$$D = u + d$$

$$D = \left(\frac{f}{i}\right)s + (f+d)$$

$$\boxed{D = Ks + C} \quad \text{—— (4)}$$

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- where, the constant (K) is $(\frac{f}{i})$ which is called as multiplying constant and the constant (C) is (f+d) which is called as additive constant.
- usually, the value of multiplying constant (K) is 100 and additive constant (C) is kept to the minimum usually equal to zero.
- The value of C varies from 0.3m to 0.6m in external focusing telescope and 0.08m to 0.2m in internal focusing telescope.
- RL of Staff Station 'Q'

Since the line of sight is assumed to be horizontal and thus the elevation of staff station Q is given by,

Elevation of Staff Station Q = elevation of line of collimation − central hair reading (CQ)
= (RL of BM + BS) − central hair reading (CQ)

problem ① The stadia readings with sight horizontal taken on a vertical staff 60m away from the tacheometer were 1.280m and 1.785m. The focal length of the object lens was 30cm and distance between object lens and vertical axis of tacheometer was 20cm. find the stadia interval.

Solution :-

Tacheometric constants are K and C

where, $C = f + d$

$= 30 + 20 = 50\,cm = 0.5\,m$

$K = \frac{f}{i}$ $\quad i \Rightarrow$ stadia interval.

Staff intercept (S) $= 1.785 - 1.280$

$= 0.505\,m$

$$D = KS + C$$

$$D = \frac{f}{i} S + C$$

$$60 = \frac{0.3}{i}(0.505) + 0.5$$

$$i = 2.546 \times 10^{-3}\,m$$

$$i = 2.546\,mm$$

$$\boxed{i = 2.55\,mm}$$

- Stadia Rod

↳ The ordinary levelling staff with 5mm graduations can be used for short distances only.

↳ For long distances, special large staff called the stadia rod is used.

↳ This stadia rod is in one piece 3m to 5m long and about 50mm to 150mm wide. The graduations are made bold and simple so that it is easy to take the readings even from a long distance.

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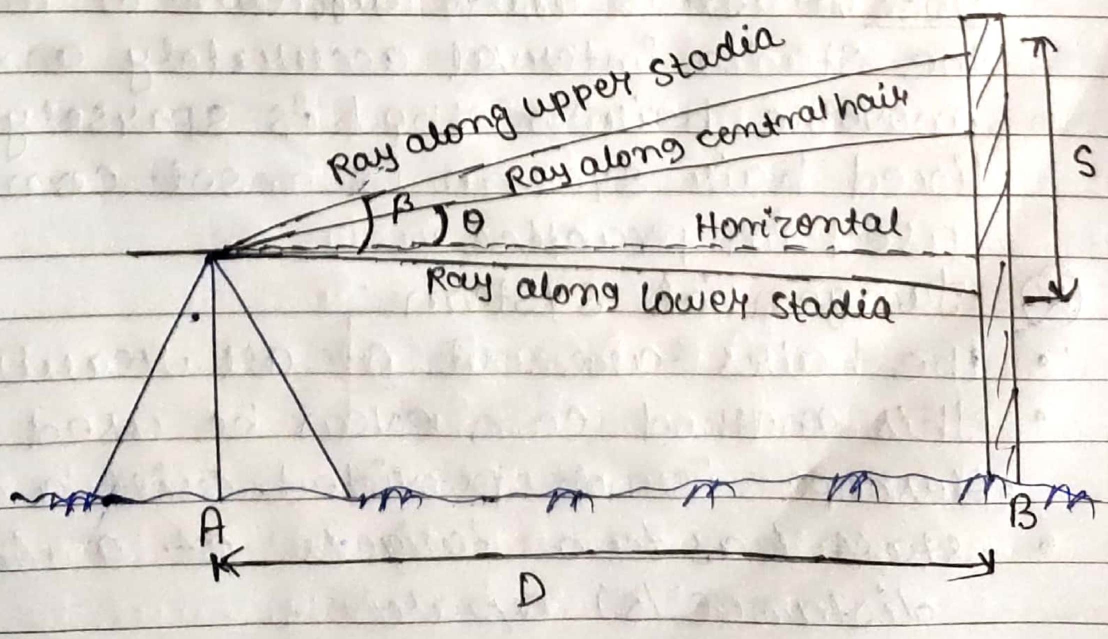
Limitations :- Because stadia rods are large and bulky, they pose inconvenience in transportation.

- Systems of Tacheometric measurements
  1. Stadia system
  2. Tangential system
  3. Subtense bar system

(1) Stadia System :- In the stadia system of tacheometry, the tacheometer is set up at station A and staff at station B.

- The staff intercept between the upper and lower stadia is measured along with vertical angle θ made with the horizontal.
- The horizontal distance D between the instrument station A and staff station B and difference of elevations between stations A and B are determined from the staff intercept (S) and the vertical angle (θ)



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- The Stadia system of tacheometry is further classified as –
① Fixed hair system
② movable hair system.

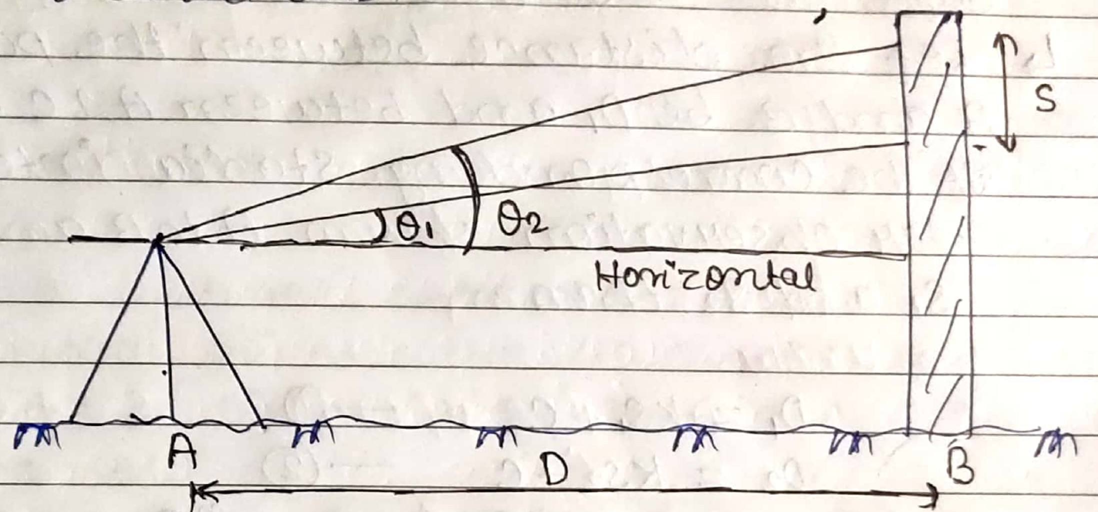
① Fixed hair system
- The vertical distance between the upper and lower stadia hair is fixed. and this fixed distance is called as stadia interval (i)
- stadia interval is not changed during the measurement.

② movable hair system
- The distance between the upper hair and lower hair is varied by moving the stadia haires vertically by the micrometer screws.
- Stadia interval is varied and is measured corresponding to the staff intercept.

Note :- It is quite difficult to measure the stadia interval accurately and thus movable hair method is sparsely used. fixed hair system is most commonly used in practice.

② Tangential system
- the haires are not at all required.
- This method can even be used when telescope is not provided with a diaphragm.
- staff has two targets at a fixed distance (s) apart.

- Vertical angles θ_1 and θ_2 are measured to the two targets.
- Now these vertical angles and the fixed distance on staff are used to determine the horizontal distance and difference of elevations.

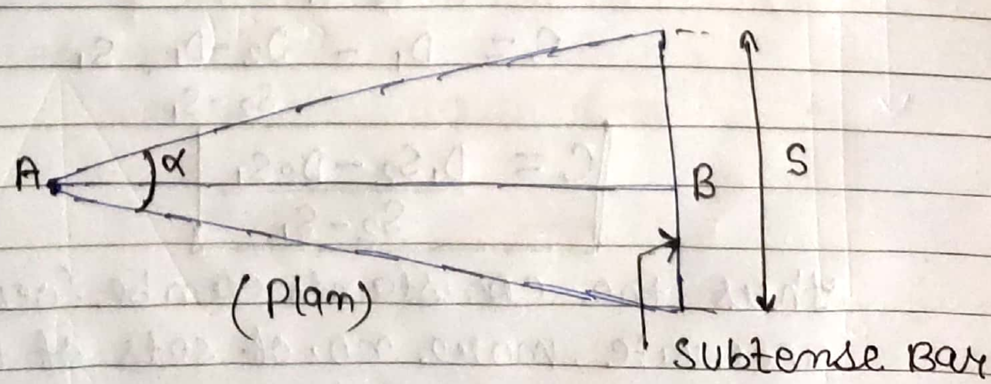


③ Subtense Bar system

↳ In this system, A bar of fixed length is used which is known as subtense bar.

↳ The subtense bar has two targets at the ends at a fixed distance (s) apart.

↳ The horizontal angle subtended between the instrument station A and the two targets on the subtense bar is measured.



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- Determination OF Tacheometric constants

↳ The best way to determine the multiplying and additive constants of a tacheometer is to take observations on a fairly level ground for two different distances.

↳ Let the distance between the points A and B be D_1 and between A & C be D_2. If the corresponding stadia intercepts for observation from A to B and C are S_1 and S_2 then,

$$D_1 = KS_1 + C \quad \text{—} ①$$

$$D_2 = KS_2 + C \quad \text{—} ②$$

Substracting eq^n ① from eq^n ② we get,

$$D_2 - D_1 = k(S_2 - S_1)$$

$$\boxed{K = \frac{D_2 - D_1}{S_2 - S_1}}$$

Substituting it in eq^n ①, we get,

$$D_1 = \frac{D_2 - D_1}{S_2 - S_1} S_1 + C$$

$$C = D_1 - \frac{D_2 - D_1}{S_2 - S_1} S_1$$

$$\boxed{C = \frac{D_1 S_2 - D_2 S_1}{S_2 - S_1}}$$

Thus, the constants can be found, To be more accurate, more no. of sets of two readings taken and then the avg. value be found.

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problem :- In order to determine the constants of a tacheometer, distances 201 and 400 m were accurately measured from the instrument and readings on a stadia rod on the upper and lower wires were taken as,

Distance in m.	Readings at lower stadia	upper stadia
201	2.00	4.00
400	0.50	4.50

Det. the values of the constants and find the distance when the readings of the stadia wires were 1.5 and 4.5 m. The line of sight being horizontal in all cases.

Solution :- From equation, we have,

$$D = \frac{f}{i} s + (f+d)$$

Let multiplying const $\frac{f}{i} = x$ and additive constant

$$f+d = y$$

$$\boxed{D = xs + y}$$

In the first case, $D = 201m$ $s = 4.00 - 2.00 = 2.00m$

then,

$$201 = 2.00x + y \quad \text{—} (I)$$

In the second case, $D = 400m$,

$$s = 4.50 - 0.50 = 4.00$$

then,

$$400 = 4.00x + y \quad \text{—} (II)$$

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Solving equations ① and ⑪

$201 = 2.00x + y$

$400 = 4.00x + y$

$- \quad - \quad -$

$199 = 2x$

$\boxed{x = 99.5}$ i.e, $\boxed{\frac{f}{i} = 99.5}$

and from eqn ①

$y = 201 - 2x$

$= 201 - 2 \times 99.5 = 2.00$

$\boxed{f+d = 2.00m}$

we know,

$D = \frac{f}{i} s + (f+d)$ $\quad S = 4.50 - 1.50 = 3.00m$

$= 99.5 \times 3 + 2$

$= 300.5m$

$\boxed{D = 300.5m}$ Ans

- Method of Tacheometry

① Stadia method

ⓐ fixed hair method

ⓑ movable hair method

② Tangential method