Theodolite:

- <u>Instrument setup:</u>

- At each station point, before taking any observation, it is required to carry out some operations in sequence. The set of operations are required to be done on an instrument in order to make it ready for taking observation.

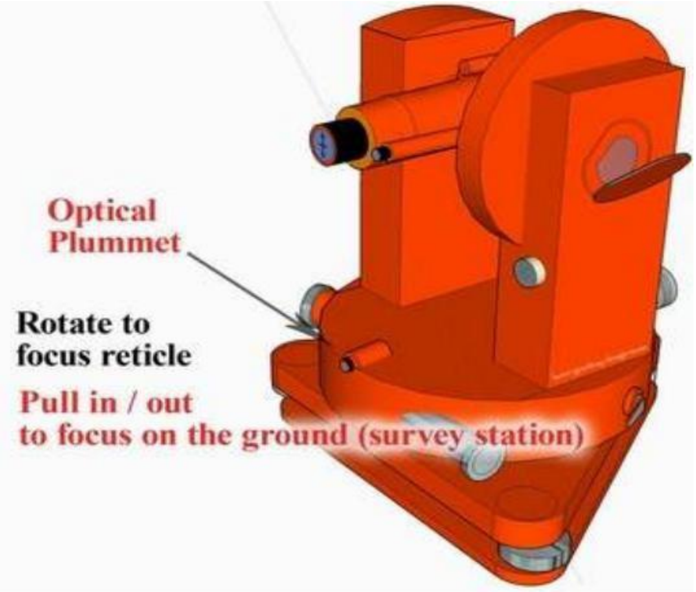
- Setting
- Centering
- Leveling
- Focusing

Theodolite:

Instrument setup:

1.Tripod height – upper about chest height to make observation easily. Place the instrument over the point with the tripod plate as level as possible. Then place the theodolite on the top of tripod. Theodolite must be hold by hand until the theodolite is attached to tripod head.

2.Check that the station point can be seen through the optical plummet. (Rotate to focus reticle – pull in or out to focus on the ground- monument)



Theodolite:

Instrument setup:

Then push in the tripod legs firmly by pressing down on the tripod shoe spurs. If the point is now not visible in the optical plumb sight, leave one leg in the ground, lift the other two legs, and rotate the instrument, while looking through the optical plumb sight. When the point is sighted, carefully lower the two legs to the ground and reseat them keeping the station point view.

While looking through the optical plumb, manipulate the leveling screws until the crosshair of the optical plummet is directly on the station mark.

Theodolite:

Instrument setup:

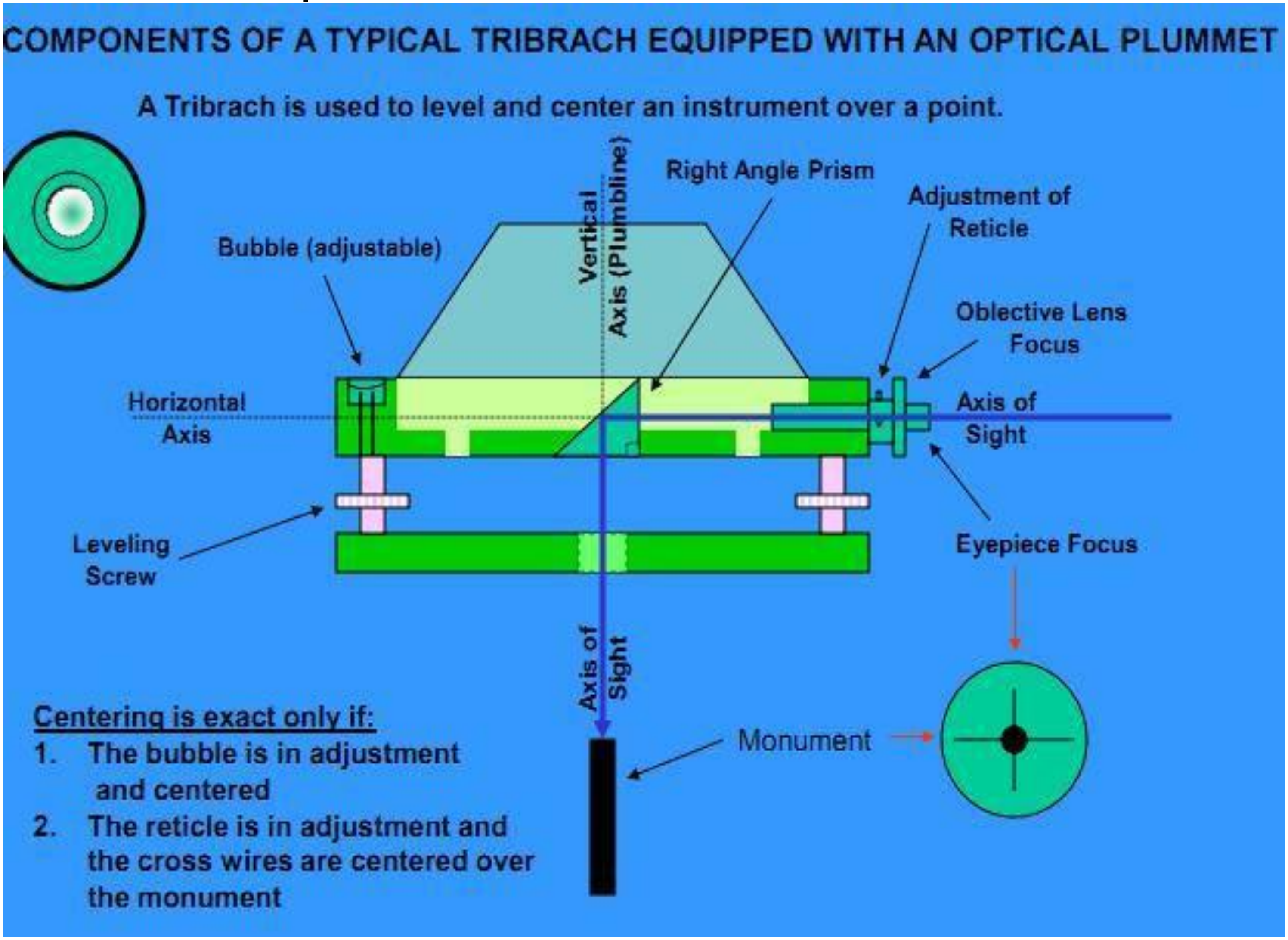


Figure:12 (E.Tarı , M.Sahin , Surveying II Lecture Notes)

Theodolite:

Instrument setup:

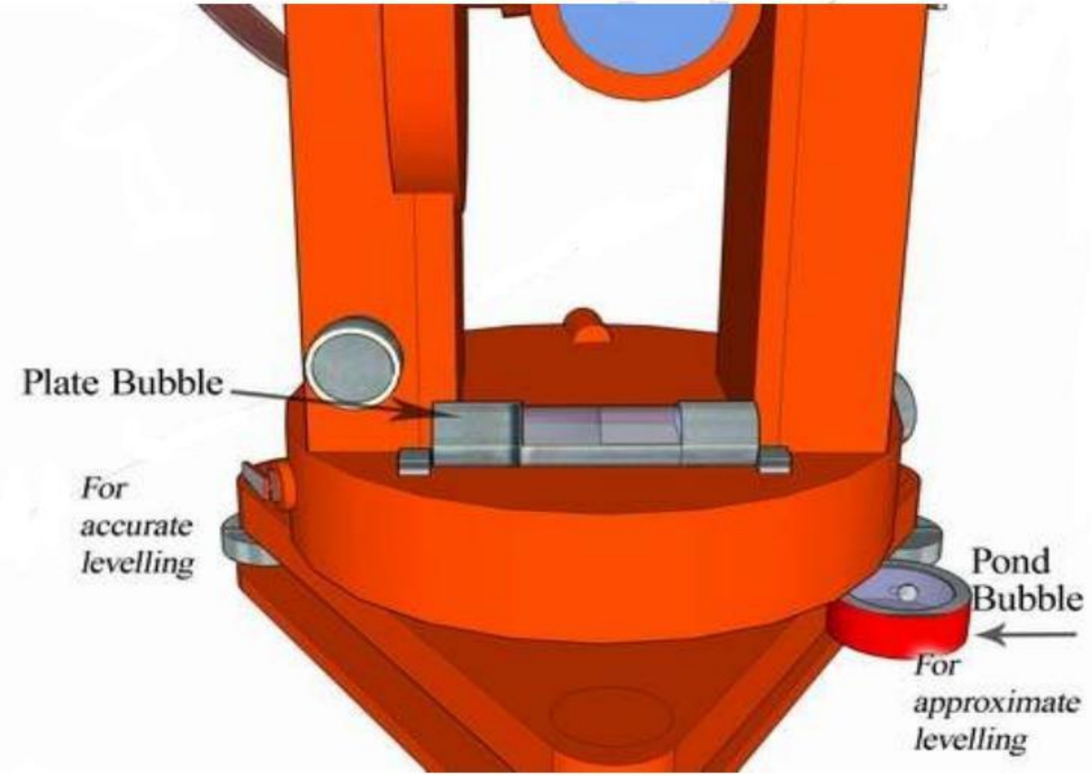


Figure:13 (H.Özener , Surveying Lecture Notes)

Theodolite:

<u>Instrument setup:</u>

3. Level the theodolite circular (pond) bubble by adjusting the tripod legs up or down (approximate leveling). This is accomplished by noting which leg, when slid up or down , moves the circular bubble toward the bull's eye. Upon adjusting the leg, either the bubble will move into the circle, or it will slide around until it is exactly opposite another tripod leg. That leg should then be adjusted up or down until the bubble moves into the circle. If the bubble does not move into the circle, repeat the process. If this has been done correctly, the bubble will be centered after the second leg has been adjusted;

Perform a check through the optical plummet to confirm that it is still being over the station mark / turn one or more leveling screws to be ensure that circular bubble is now exactly centered (if necessary).

Theodolite:

Instrument setup:

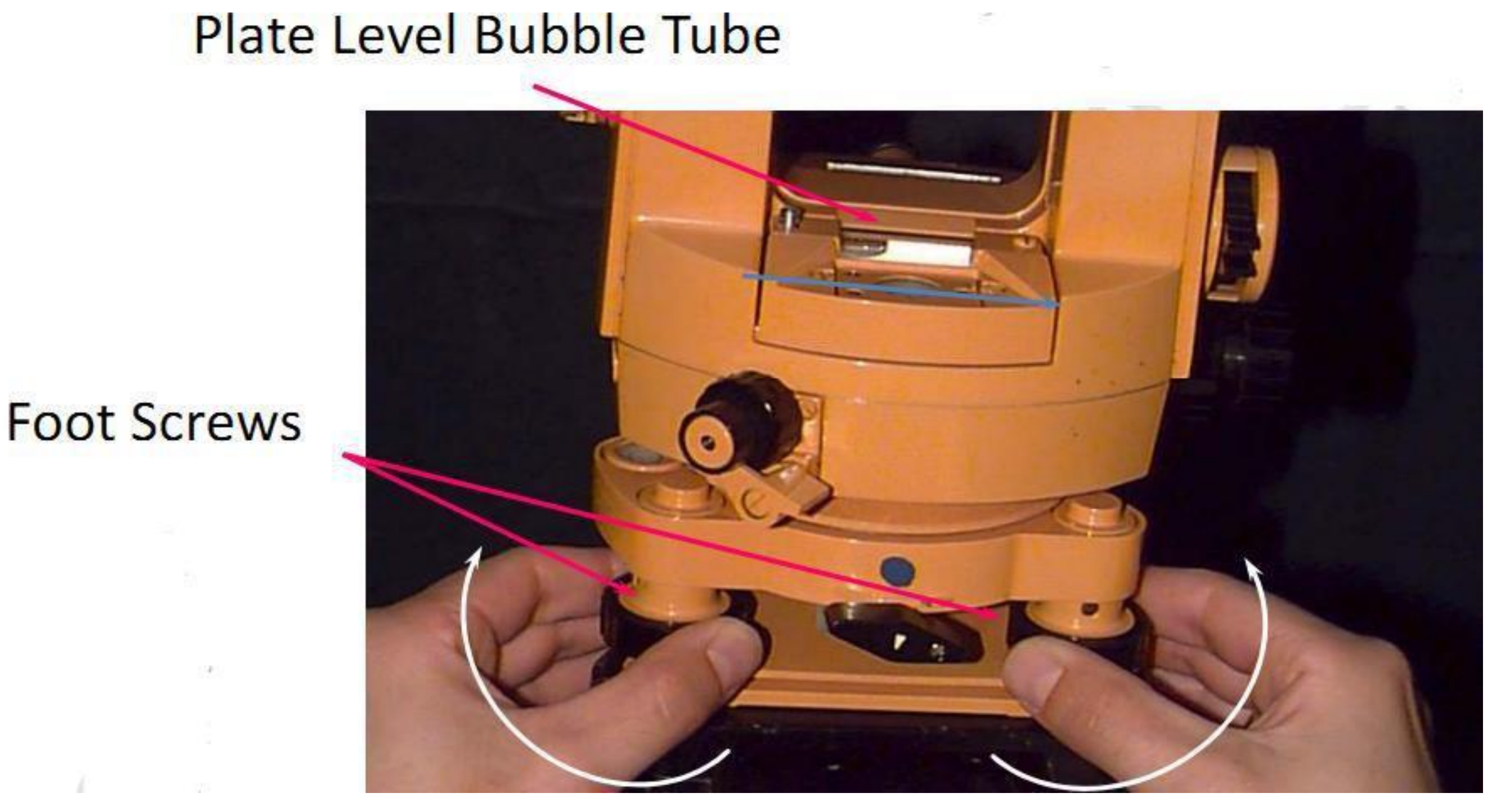


Figure:14 H.Özener Surveying Lecture Notes)

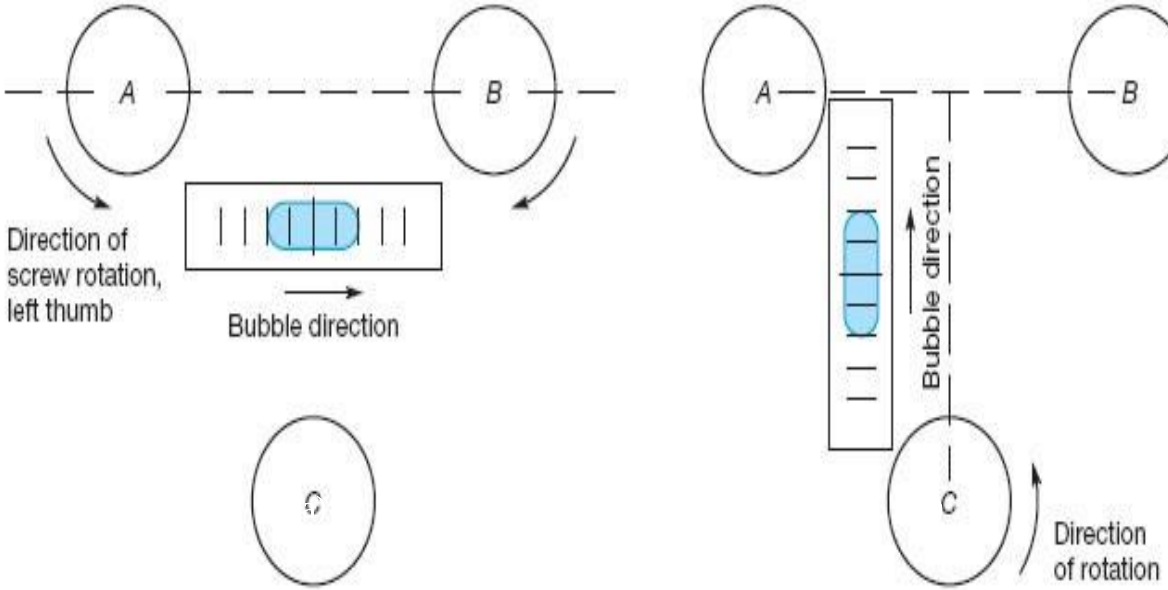
Theodolite:

Instrument setup:

The instrument can be now be leveled precisely by centering the plate (tubular) bubble.

a) Set the plate bubble so that it is aligned in the same direction as two of the foot screws. Turns these two screws in opposite direction until the bubble is centered.

b) Turn the instrument 100^g , at which plate bubble will be aligned with the third leveling (foot) screw. Finally turn that third screw to center bubble.



Theodolite:

Instrument setup:

Finally, check the axis of plate bubble should be in a plane perpendicular to the vertical axis. It is always checked by turning the instrument through 200^g . If the plate bubble is centered , the instrument is leveled.

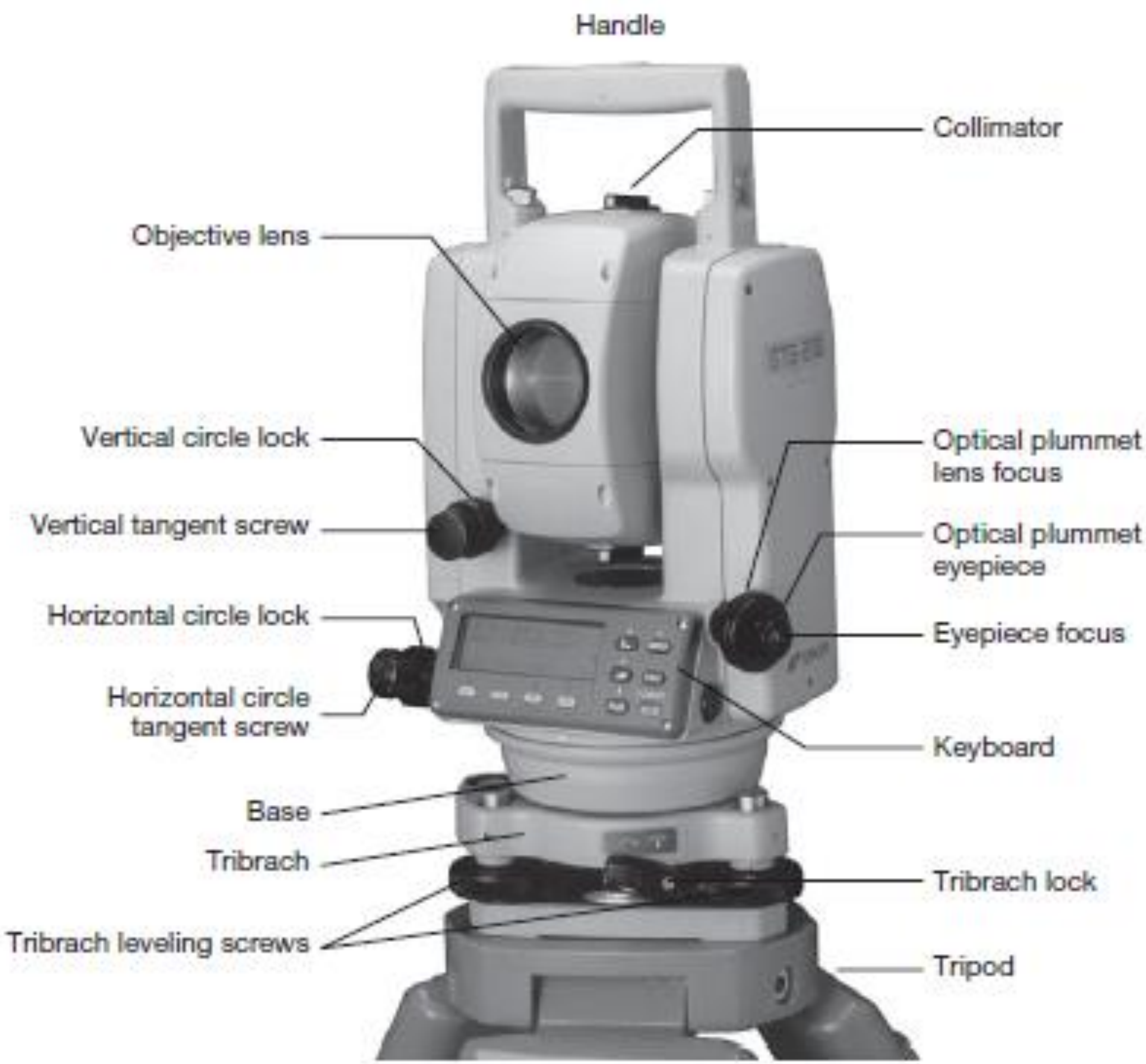


Figure 8.2
Parts of a total station instrument with view of objective end of the telescope. (Courtesy Topcon Positioning Systems.)

Theodolite:

- When moving between setups in the field, proper care should be taken. Before the total station is removed from the tripod, the foot screws should be returned to the midpoints. The instrument should NEVER be transported on the tripod since this causes stress to tripod head, tribrach, and instrument base. Figure 8.6(a) depicts the proper procedure for carrying equipment in the field. With adjustable-leg tripods, retracting them to their shortest positions and lightly clamping them in position can avoid stress on the legs.

- When returning the total station to its case, all locking mechanisms should be released. This procedure protects the threads and reduces wear when the instrument is jostled during transport and also prevents the threads from seizing during long periods of storage. If the instrument is wet, it should be wiped down and left in an open case until it is dry as shown in Figure 8.6(b).When storing tripods, it is important to loosen or lightly clamp all legs. This is especially true with wooden tripods where the wood tends to expand and contract with humidity in the air. Failure to loosen the clamping mechanism on wooden tripods can result in crushed wood fibers, which inhibit the ability of the clamp to hold the leg during future use.

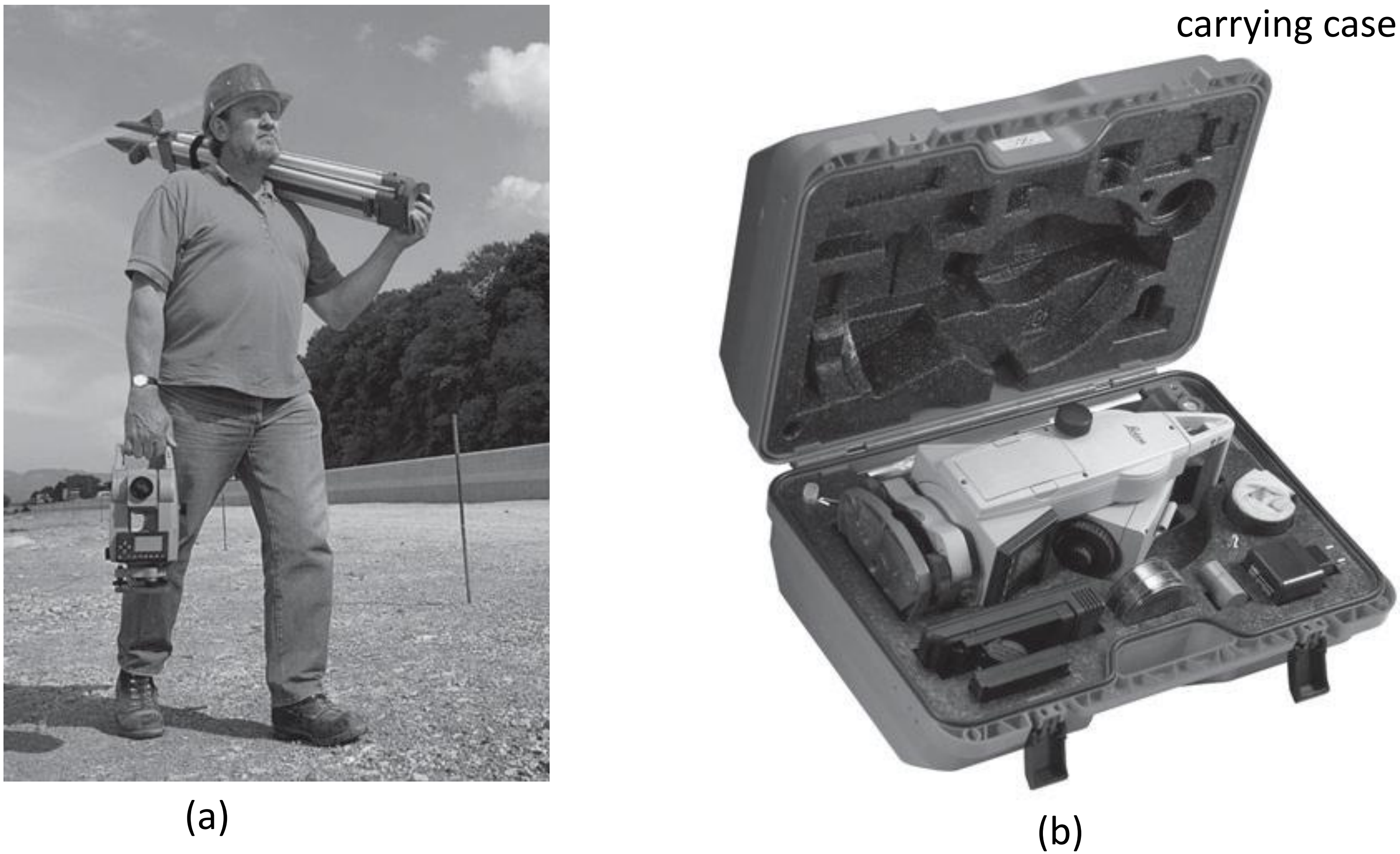


Figure 8.6 (a) A proper method of transporting a total station in the field. (b) Total station in open case.

Sight and mark

- Objects commonly used for sights when total station instruments are being used only for angle observations include prism poles, chaining pins, pencils, plumb-bob strings, reflectors, and tripod-mounted targets. For short sights, a string is preferred to a prism pole because the small diameter permits more accurate sighting.

Sight and mark

- . Triangular marks placed on prisms as shown in Figure 8.16(a) provide excellent targets at both close and longer sight distances.

(a) Prism and sighting target with tribrach and tribrach adapter, and (b) pole and bipod, used when measuring distances and horizontal angles with total station instruments. (Courtesy Topcon Positioning

Sight and mark

- The prism pole shown in Figure 8.16(b) has graduations for easy determination of the prism’s height. The tripod mount shown in Figure 8.16(a) is centered over the point using the optical plummet of the tribrach. When sighting a prism pole, the vertical cross hair should bisect the pole just below the prism

(a) Prism and sighting target with tribrach and tribrach adapter, and (b) pole and bipod, used when measuring distances and horizontal angles with total station instruments. (Courtesy Topcon Positioning

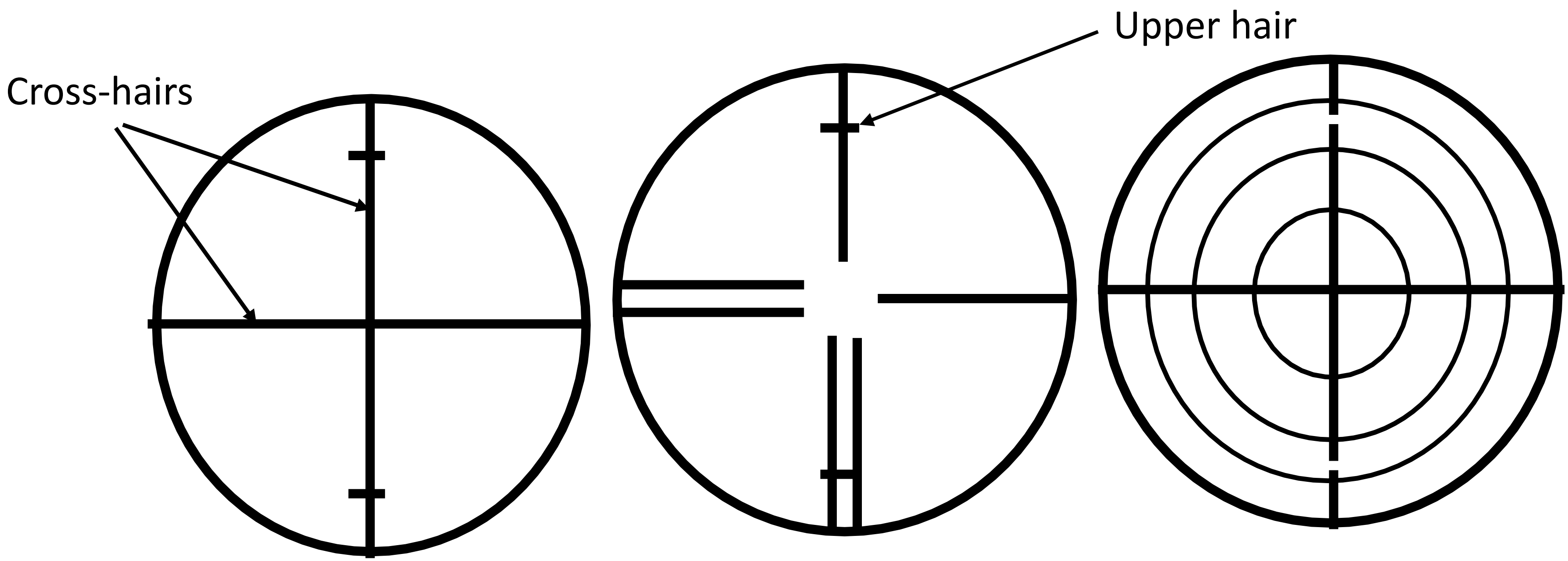
Theodolite Sightings:

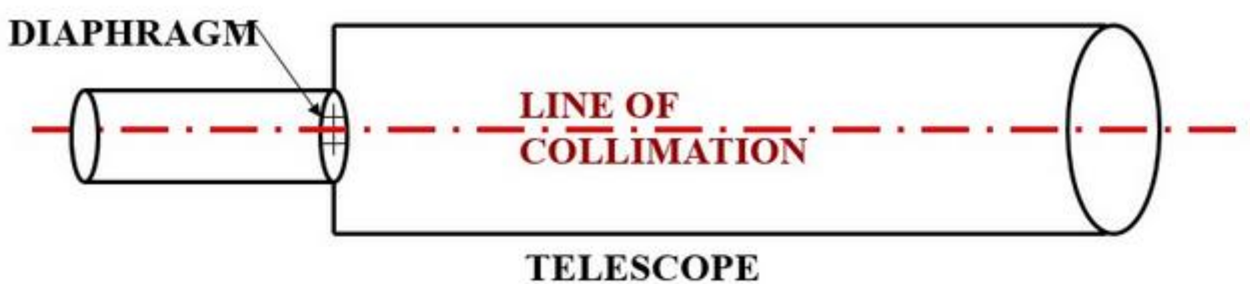
The telescope, have reticles with crosshairs etched on glass, and are equipped with rifle sight or collimators for rough pointing. Most telescope have two focusing controls. The objective lens control is used to focus on the object being viewed. The eyepiece control is used to focus on reticle. If the focusing of the two lenses is not coincident, a condition known as “parallax” will exist.

Theodolite Sightings:

Some typical theodolite diaphragms:

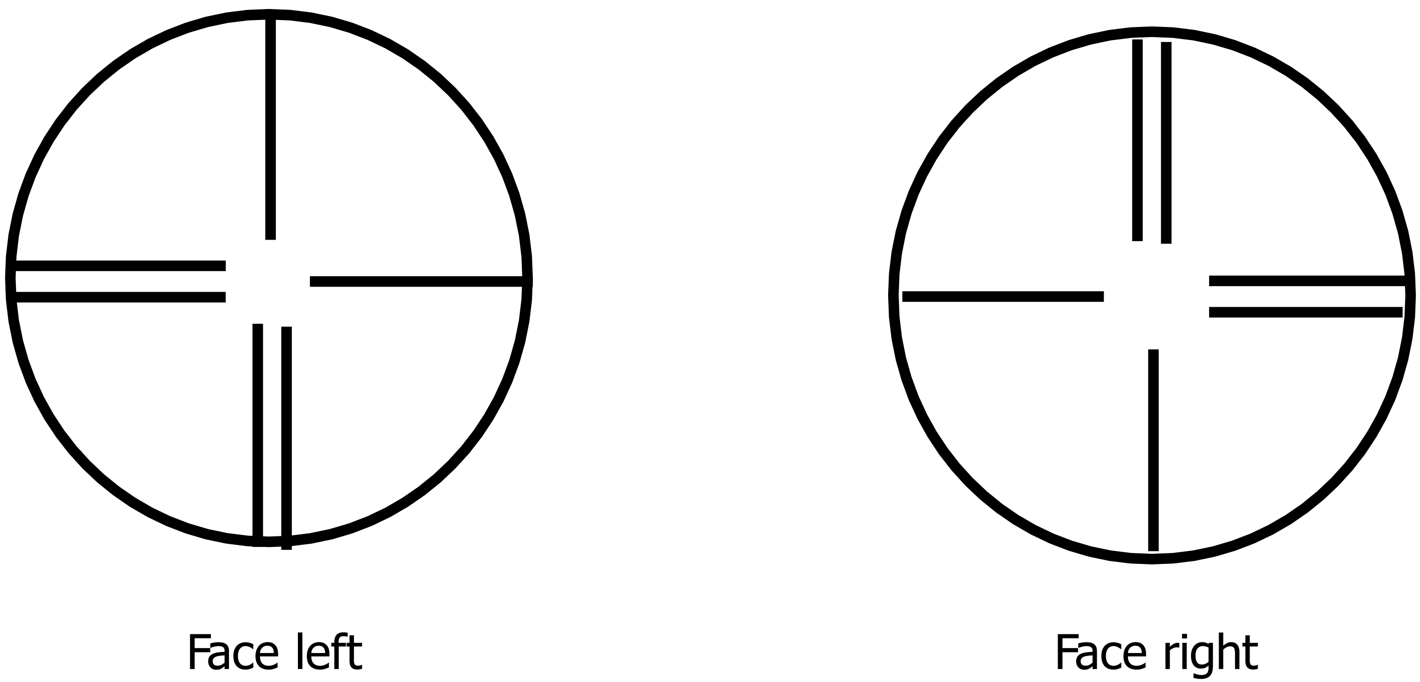
Diaphragm is a frame carrying cross-hairs and placed at the plane at which vertical image of the object is formed by the objective.





Theodolite Sightings:

Some typical theodolite diaphragms:



(Figure:17)

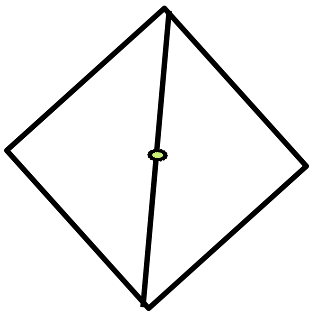
Theodolite

- **Face right**: When the vertical circle of a theodolite is on the right of the observer the position is called face right and the observation made is called face right observation.
- **Face left**: When the vertical circle of a theodolite is on the left of the observer the position is called left right and the observation made is called face left observation.

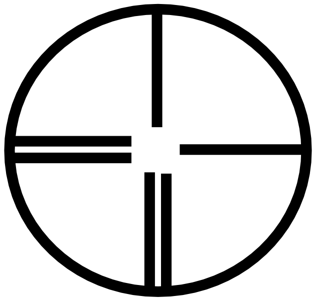
- **Changing face**: The operation of bringing the vertical circle from one side of the observer to the other is known as changing face.

- revolving the telescope by 180 degrees in vertical plane about horizontal axis.
- Again revolving the telescope in horizontal plane about vertical axis.

Theodolite Sightings:



This is the sort of target that we have fixed to the wall outside



we need to superimpose the theodolite diaphragm over the target.

Going for the centre point is difficult particularly if the central line of the target is not vertical.

Theodolite Sightings:

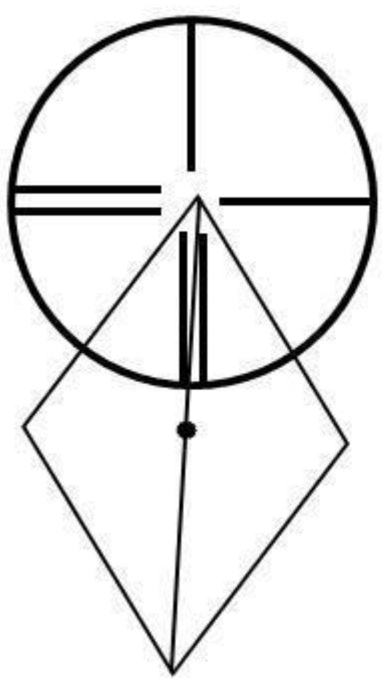


Figure: 18

Because of the “hole” in the lines of the diaphragm this is still not good practice. I am not sure that I am lined up on the top point.

Theodolite Sightings:

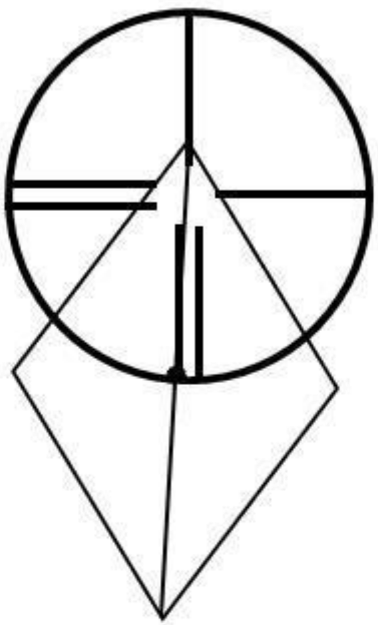


Figure: 19

This is much better. I can repeat this alignment with a fair degree of certainty.

This is how we should sight a target for horizontal angle.

Observing horizontal angles:

- Horizontal angles are observed in horizontal planes. The theodolite is set properly over the instrument station and leveled, sight on the left-hand station (usually), clamp the horizontal movement, and then set the vertical crosshair precisely on the station by using the fine adjustment screws; second, set the scales to zero(usually) or some other required value by turning the appropriate screws; third, loosen the clamp and turn the instrument until it is pointing at the second (foresight) station, set the clamp and use the fine adjusting screw to precisely sight the vertical crosshair on that station; fourth, read and book the angles. To help eliminate mistakes and to improve precision, angles are measured twice.

Observing horizontal angles:

Firstly, re-sight the second station point (right-hand or foresight) in Face II as described above and then re-sight first station point (left-hand or backsight) in Face II. The mean angle determined by direct and reversed observations.

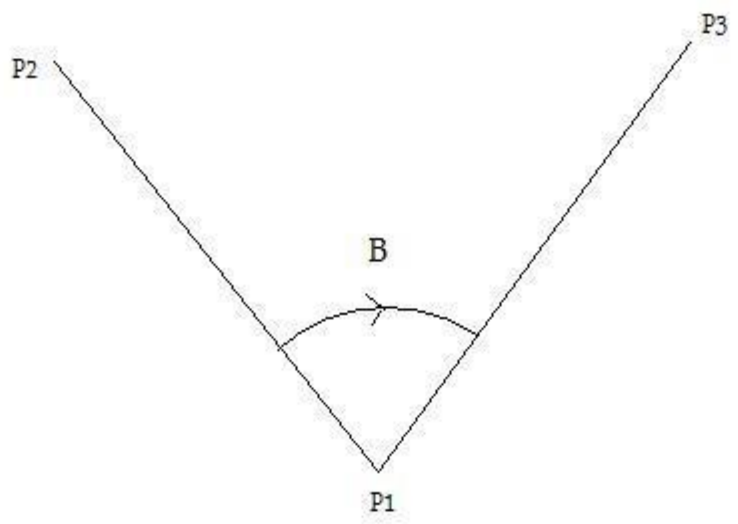


Figure:25

P1 – station point

P2 – left target (backsight)

P3 – right target (foresight)

B : horizontal angle (clockwise)

Face I = P2 then P3 observations

Face II =P3 then P2 observations

Observing horizontal angles:

To measure an *angle set* with a theodolite:

- Point to the backsight in the direct position, lock on the target and record the plate reading. Although not mathematically necessary, we set he horizontal circle to zero to simplify the calculations and to aid in any necessary debugging of the data.
- Loosen the horizontal motion and turn to the foresight. Lock the horizontal motion, perfect the sighting, then record the horizontal plate reading.
- Loosen both horizontal and vertical motions, plunge telescope and point to the foresight. Again (in the reverse position) lock the horizontal motion, perfect the sighting and record the horizontal plate reading.
- Loosen the horizontal motion and turn to the backsight, lock the horizontal motion, perfect the sighting and record the horizontal plate reading.

This completes one set. Depending on the accuracy required additional sets should be maked.

Observing horizontal angles:

	FIELD BOOK FOR ANGULAR MEASUREMENTS - HORIZONTAL ANGLE						
	Station	Target	Horizontal Direction (GRAD)		Mean	Reduced	mean of sets
	Point	Point	Face I	Face II	$(F_{II} - 200 + F_I)/2$	directions(GRAD)	(GRAD)
SET1	P_2	P_1	0.650	200.652	0.651	0.0000	148.647
		P_3	149.298	349.296	149.297	148.646	
SET2	P_2	P_1	100.323	300.325	100.324	0.0000	
		P_3	248.971	48.973	248.972	148.648	

PROJECT :		GROUP NO:	
LOCATION:		BOOKER:	
WEATHER:		OPERATOR:	
EQUIPMENT:		DATE:	

Observing vertical angles:

A zenith angle is read on the vertical circle after pointing at a target.

A reading on the vertical circle should be 100^g if the line of sight is horizontal. There is a so-called index error if this requirements is not fulfilled. It is possible to avoid this error by measurement in both positions of the telescope and by calculation of correction.

Observing vertical angles:

- If there is no index error;

  $Z_1 + Z_2 = 400^g$

- If there is an index error;

  $Z_1 + Z_2 = 400^g + 2i$

  $i = (Z_1 + Z_2 - 400^g) / 2$

- and corrected zenith angle

  $Z = Z_1 - i$

Observing vertical angles:

FIELD BOOK FOR ANGULAR MEASUREMENTS - VERTICAL ANGLE						
Station	Target	Vertical Angles (GRAD)		ε	Zenith Angle	mean of sets
Point	Point	Face I	Face II	$(400-(F_{II}+F_{I}))/2$	Face I + ε	Zenith(GRAD)
P_2	P_1	84.130	314.876	-0,003	85.127	85.126
P_2	P_1	85.128	314.880	-0,004	85.124	

PROJECT :		GROUP NO:	
LOCATION:		BOOKER:	
WEATHER:		OPERATOR:	
EQUIPMENT:		DATE:	

Errors in Angular measurement:

<u>Natural error:</u>

- Wind
- Temperature effects
- Refraction
- Tripod settlement

Errors in Angular measurement:

Personal error:

- Instrument not set up exactly over point
- Bubbles not centered perfectly
- Improper use of clamps and tangent screws
- Poor focusing
- Overly careful sights
- Careless plumbing and placement of rod

Errors in Angular measurement:

Instrumental errors:

- Plate bubble out of adjustment
- Horizontal axis not perpendicular to vertical axis
- Axis of sight not perpendicular to horizontal axis
- Vertical-circle indexing error
- Eccentricity of centers
- Circle graduation errors
- Errors caused by peripheral equipment

Errors in Angular measurement:

<u>Instrumental errors:</u>

For a properly adjusted instrument, the four axes must bear specific relationship each other. If these relationships are not true, errors will result in measured angles unless proper field procedures are observed. A discussion of errors caused by mal-adjustment of these axes and other sources of instrumental errors follows;

1. *<u>Plate bubble out of adjustment:</u>* If the axis of the plate bubble is not perpendicular to the vertical axis, the latter will not truly vertical when the plate bubble is centered. This condition causes errors in observed horizontal and vertical angles that cannot be eliminated by averaging direct and reserved readings. The plate bubble is out of adjustment if after centering, it runs when the instrument is rotated 200^g .

Errors in Angular measurement:

<u>Instrumental errors:</u>

Set the plate bubble so that it is aligned in the same direction as two of the foot screws. Turns these two screws in opposite direction until the bubble is centered.

When the instrument is rotated 200^g. The amount of bubble run indicates twice error that exists. The half amount of bubble run can be eliminated by turning leveling screws and the other half of error can be eliminated by turning plate bubble adjustment screw with suitable direction. Then the adjustment must be controlled again.

2. <u>Horizontal axis not perpendicular to vertical axis:</u> After leveling and focusing, the error can be determined that carefully pointing to the same targets (points higher or lower than theodolite height) in both direct and reversed modes. If an adjustment is necessary, the qualified technician should adjust this condition in laboratory environment.

Errors in Angular measurement:

Instrumental errors:

Axis of sight not perpendicular to horizontal axis: If this condition exists, as the telescope is plunged, the axis of sight generates a cone whose axis coincides with the horizontal axis of instrument. This error can be determined that pointing to a target in both face left and face right.

Vertical circle indexing error: when the axis of sight is horizontal, an altitude angle of zero, or a zenith angle of either 100^g or 300^g should be read; otherwise an indexing error exists. The error can be eliminated by computing mean from equal numbers of altitude or zenith angles read in the direct and reversed modes.

Eccentricity of centers: this condition exists if the geometric center of the graduated horizontal or vertical circle does not coincide with its center of rotation.

Errors in Angular measurement:

Instrumental errors:

Circle graduation errors: If the graduations around the circumference of a horizontal or vertical circle are nonuniform, errors in observed angles will result.

Errors caused by peripheral equipment: Additional instrumental errors can result from worn tribrachs, optical plummets that are out of adjustment, unsteady tripods, and sighting poles with maladjusted bull's eye bubbles. This equipment should be regularly checked and kept in good condition or adjustment.