ENGINEERING SURVEYING (221 BE)

KOLEJ UNIVERSITI LINTON
UNIVERSITY COLLEGE

Coventry University

Theodolite & Total Station

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INTRODUCTION

- Until recently, transits and theodolites were the most commonly used surveying instruments for angle measurements for angle measurement. These two devices were fundamentally equivalent and could accomplish basically the same task
- Today, total station accomplish all the task much more efficiently than transits and theodolite
- In addition, it can observes distance accurately and quickly
- Furthermore, it can make computations with the angle and distance measurements and display the result in real time
- It is used for all types of surveys including topographic, hidrographic, cadastral, and construction surveys

TRANSIT AND THEODOLITE

- Primary function is the accurate measurement of layout of horizontal and vertical angles

- Other function
  - ✓ Determining horizontal and vertical distances by stadia
  - ✓ Extending straight lines
  - ✓ Differential levelling

DEFINITION

- Transits and theodolites operate on the same basic principles

- No universally accepted difference between the terms “transit” and “theodolite”

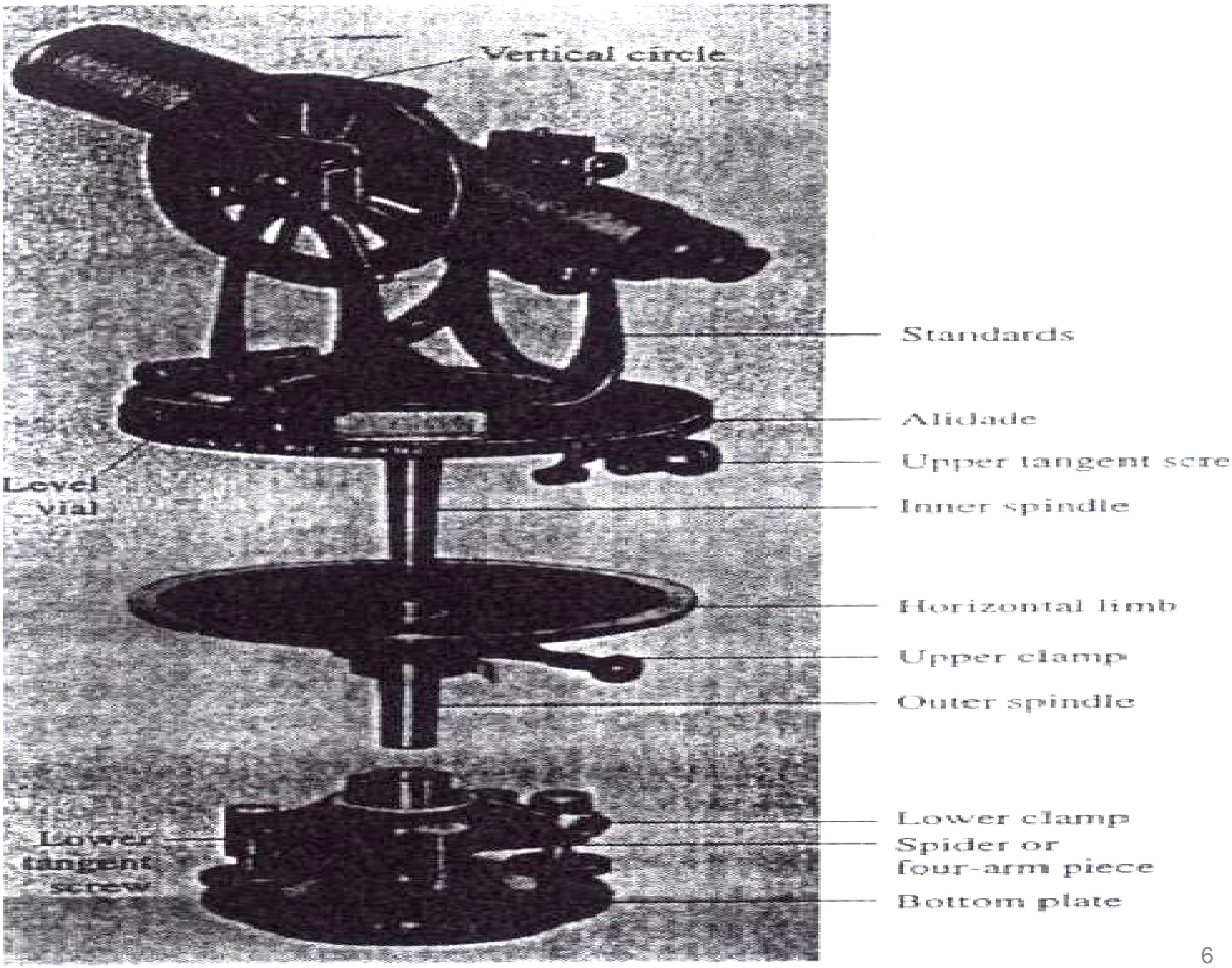
- Distinguishing characteristics:
  - ✓ Transits have an open design where the measurements are made by reading verniers on metal circles
  - ✓ Theodlites have a closed designed where the measurements are made by reading verniers etched on glass circles
  - ✓ Theodolites are capable of greater precision and accuracy

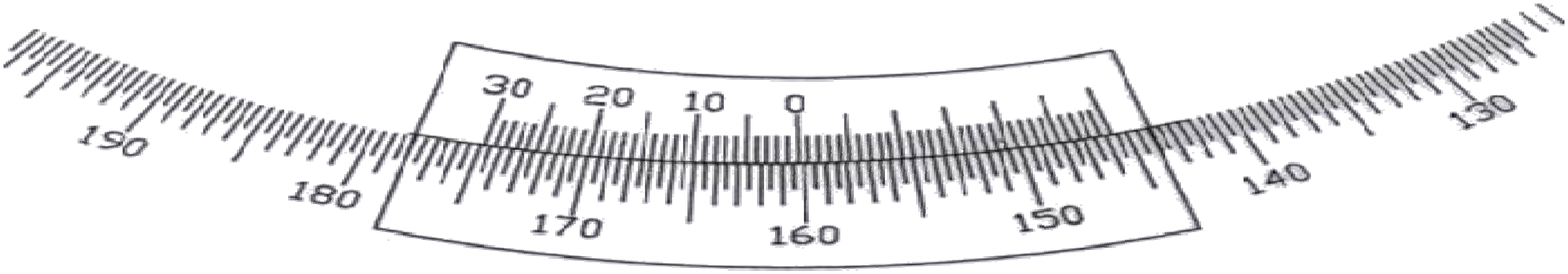
TRANSIT

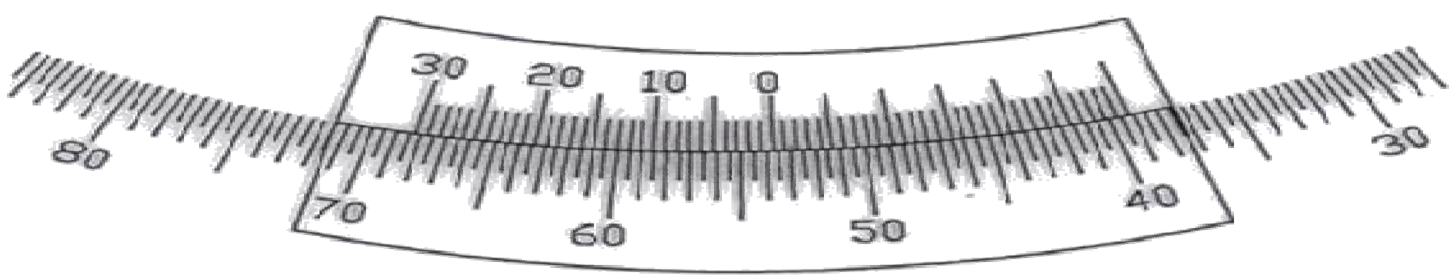
Transit is the most universal of surveying instruments – primary use is for measurement or layout of horizontal and vertical angles – also used to determine vertical and horizontal distance by stadia, prolonging straight lines, and low-order leveling

6 Components of the Transit

1. Alidade – Upper part
2. Horizontal limb – Middle part
3. Levelling-head assembly – Lower part
4. Levelling Haed
5. Scales (range from 30” to 10”)
6. Transit vernier (range from 1” to 10”)


Vertical circle
Standards
Alidade
Upper tangent scre
Level vial
Inner spindle
Horizontal limb
Upper clamp
Outer spindle
Lower clamp
Lower tangent screw
Spider or four-arm piece
Bottom plate


30
20
10
0
190
180
170
160
150
140
130


30
20
10
0
80
70
60
50
40
30

THEODOLITE

- The theodolite is used to measure horizontal and vertical angles for exact survey work

- Compared to transit, theodolite are:
  - ✓ Compact
  - ✓ Lightweight
  - ✓ More accuracy and precise

- Transits are more common in the U.S. but are being replaced by theodolite

TYPE OF THEODOLITE

- ❑ Repaeting theodolite
- ❑ Directional Theodolite
- ❑ Electrical Digital Theodolite
- ❑ Total Station

REPEATING THEODOLITE

- This design enables horizontal angles to be repeated any number of times and added directly on the instrument circles

- Advantages of this design are:

  - ✓ Better accuracy obtained through averaging
  - ✓ Disclosure of errors and mistakes by computing values of the single and multiple readings

REPEATING MEASUREMENT

- Measure the angle (e.g. 23° 19')
- Tighten the lower motion clamp
- Re-sight on the initial point
- Sight the second point and re-measure the angle (e.g. 46° 40")
- Repeat process as many times as desired
- Solution equals the average of the measurement, or the final measurement divided by the number of measurements

- For example:
  - ✓ 1st measurement : 23° 19'
  - ✓ 2nd measurement : 46° 40'
  - ✓ 3rd measurement : 69° 59'
  - ✓ 4th measurement : 93° 23'
  - ✓ 5th measurement : 116° 44'
  - ✓ 6th measurement : 140° 32'
  - ✓ Average angle measurement : 23° 20'

DIRECTIONAL THEODOLITE

- Non-repeating instrument that has no lower motion
- Reads "directions" rather than angles
- Angles are obtained by subtracting the first direction reading from the second direction reading

DIRECTIONAL MEASUREMENT

- Set up the theodolite
- Sight the initial point and read the direction
  (e.g. 31° 19’ 27”)
- Sight the second point and read the direction
  (e.g. 85° 24’ 49”)
- The angle is then calculated as the difference between the two directions
  (e.g. 54° 05’ 22”)

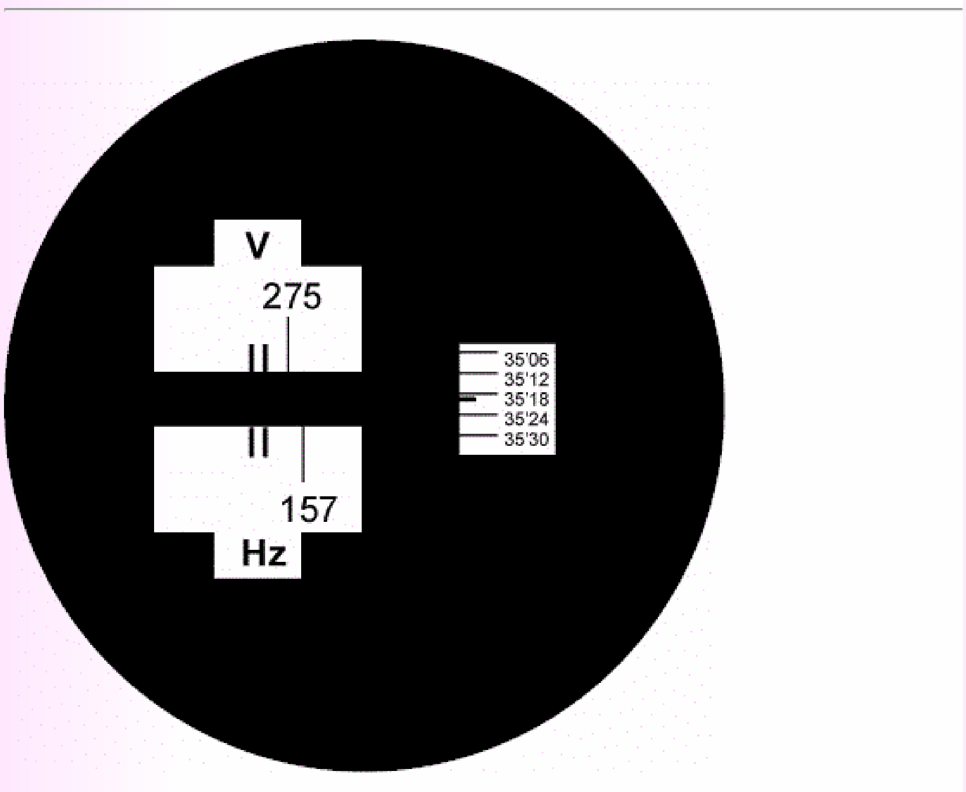
ELECTRONIC DIGITAL THEODOLITE

- Automatically reads and records horizontal and vertical angles
- Eliminates the manual reading of scales on graduated circles

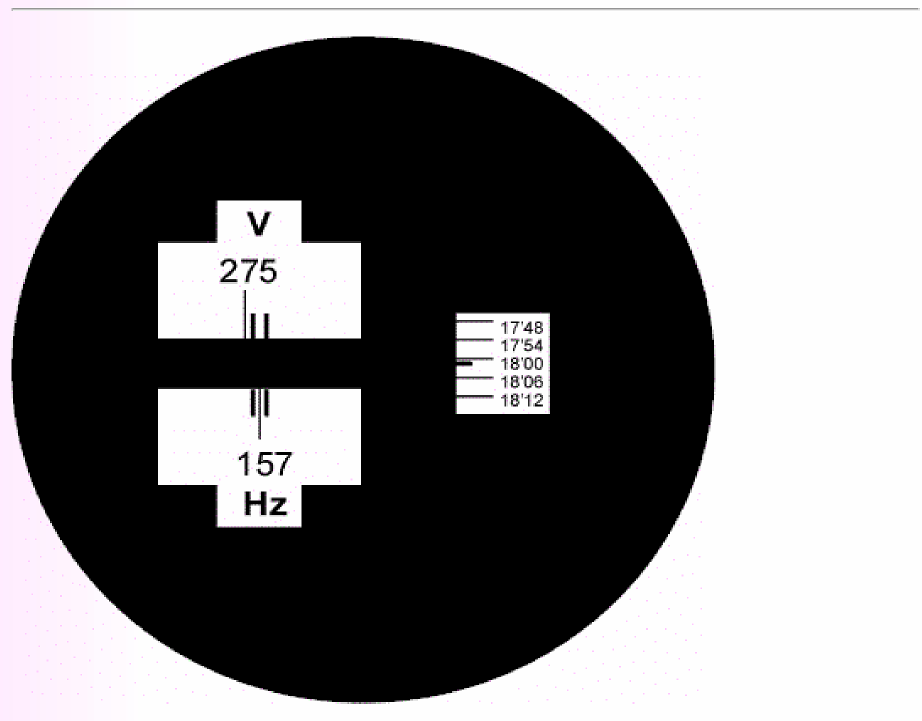
ADVANTAGES OF ELECTRONIC DIGITAL THEODOLITE

- Circles can be instantaneously zeroed, or initialized to any value
- Angles can be measured with increasing values either left or right
- Angles measured by repetition can be added to provide a total larger than 360°
- Mistakes in reading angles are greatly reduced
- Speed of operation is increased
- Cost of instrument is lower

THEODOLITE READING



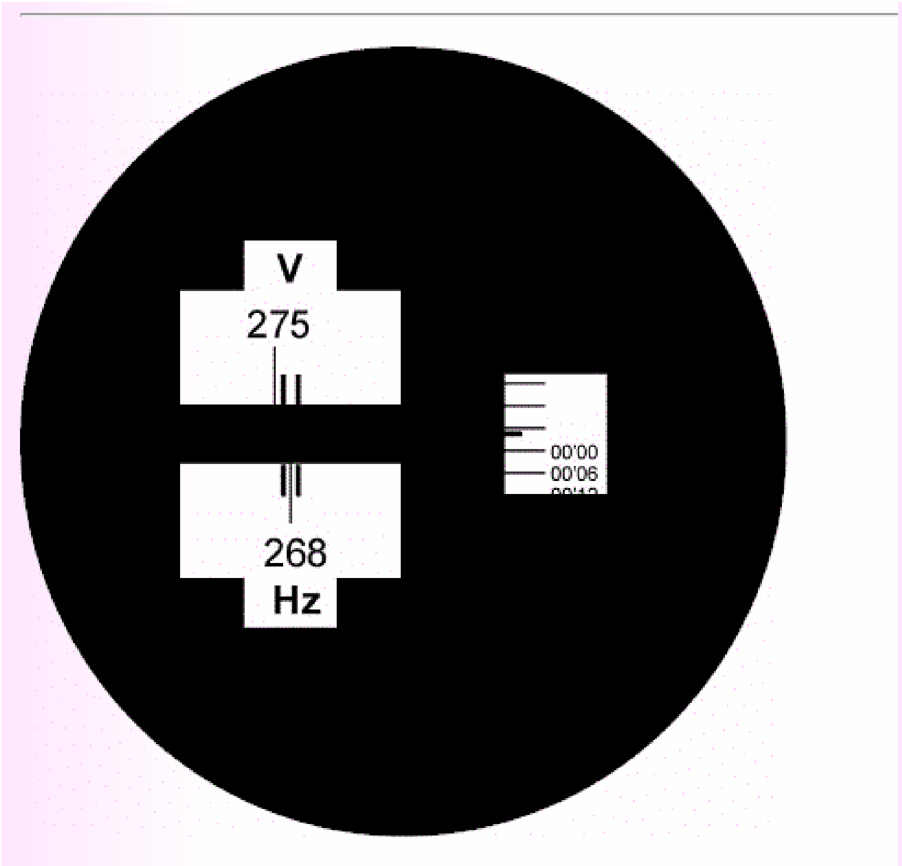
157° ??' ??"



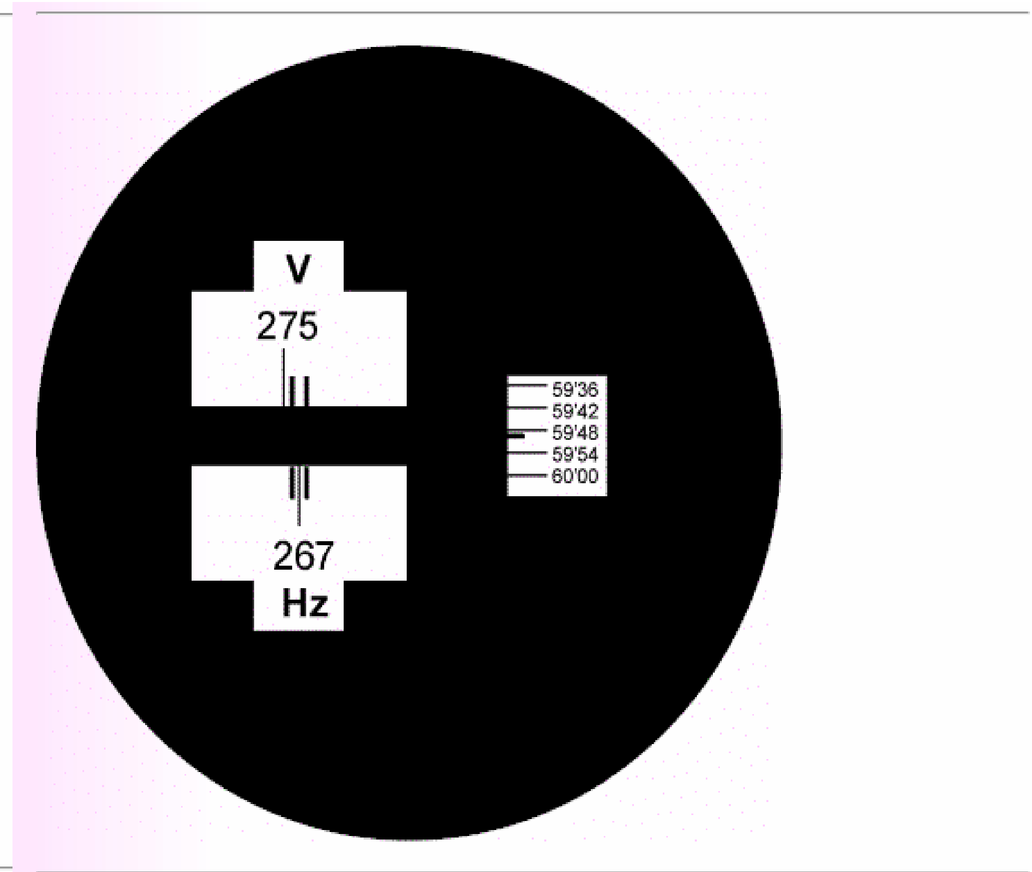
157° 18' 00"

157° 18' 02"

THEODOLITE READING

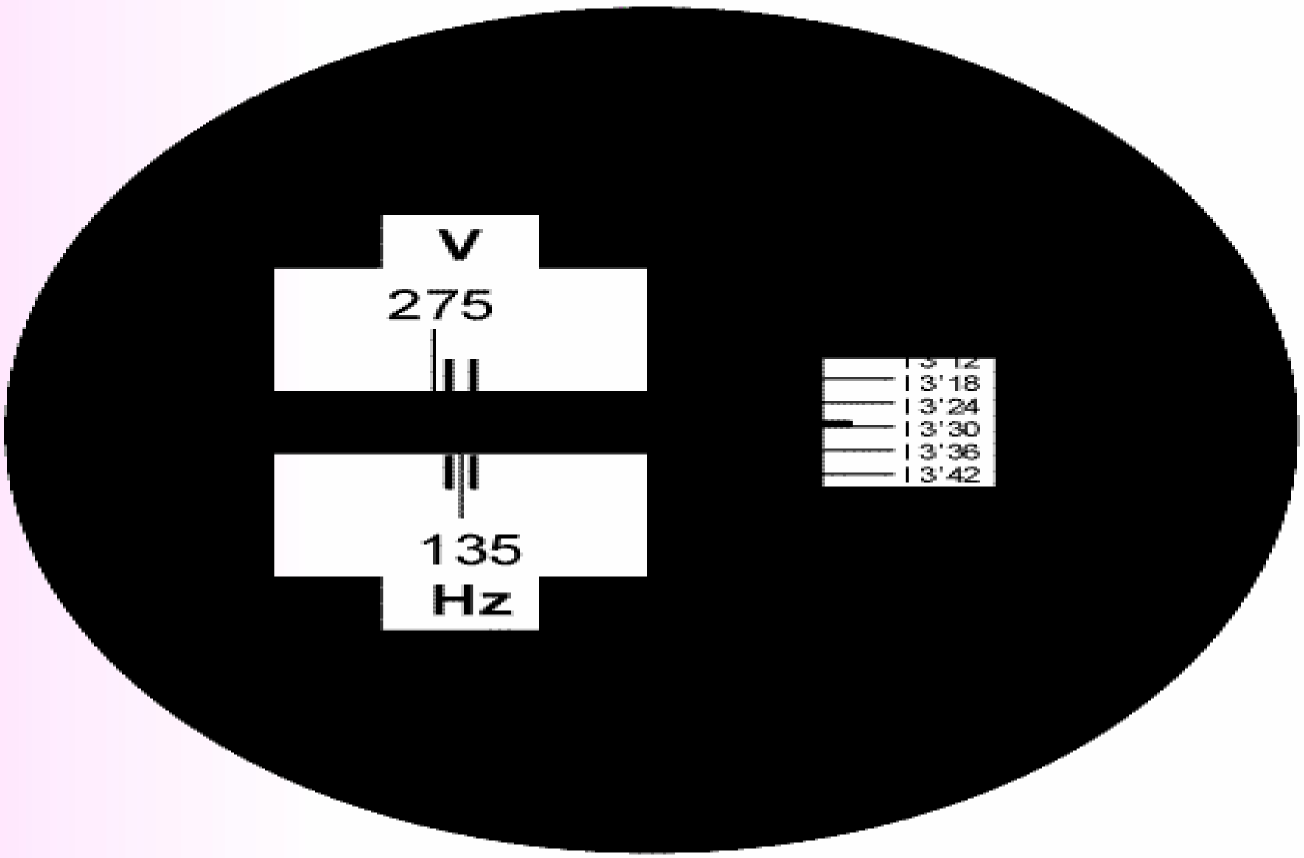


Just less than 268°



267° 59' 50"

THEODOLITE READING

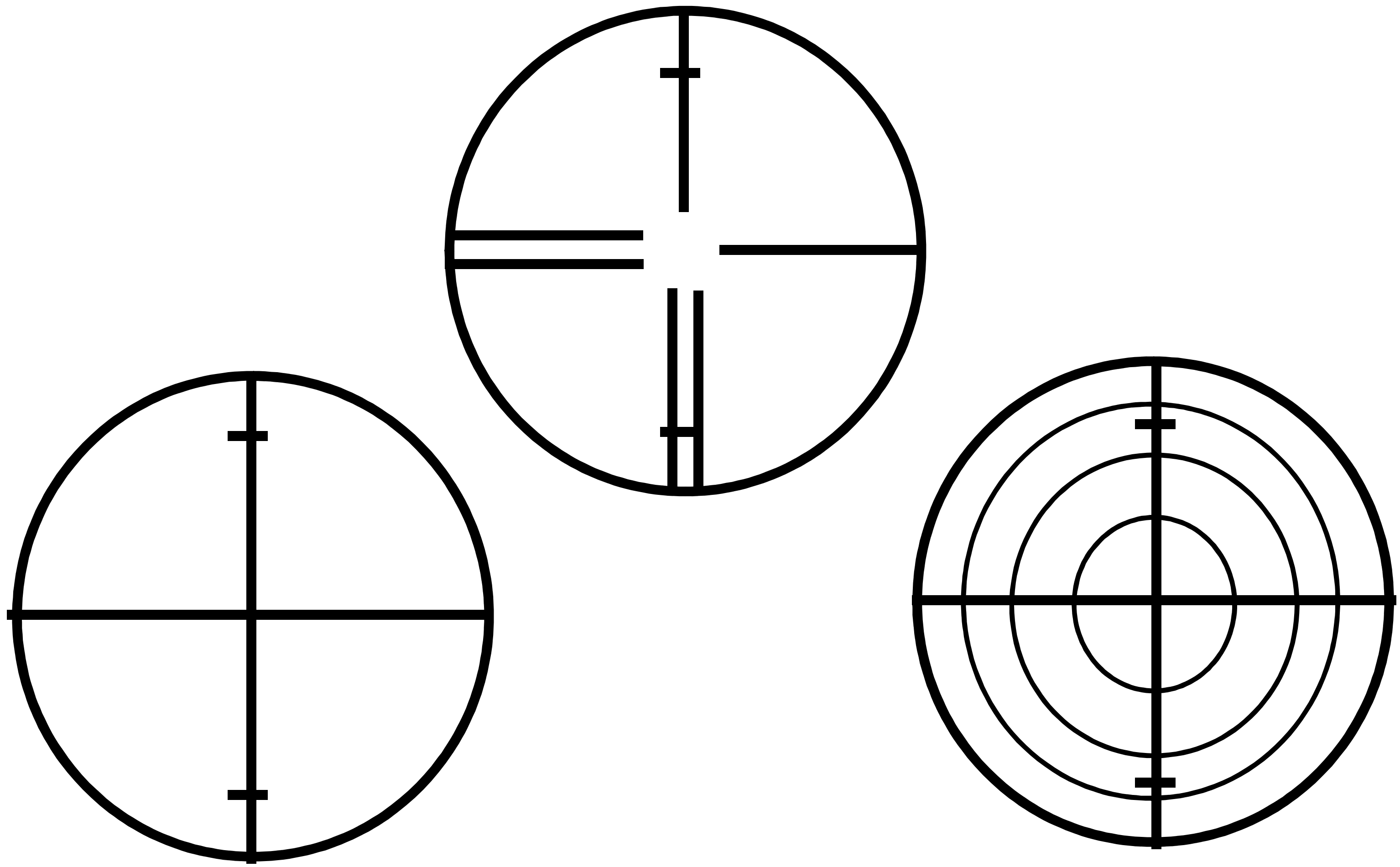


135° 03' 30" WRONG

135° 13' 30" RIGHT

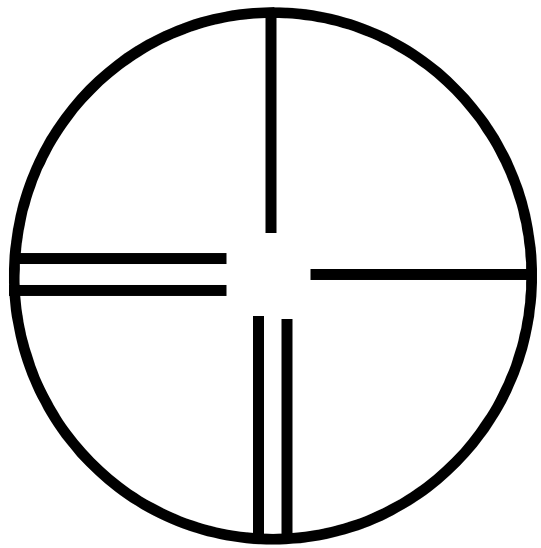
THEODOLITE SIGHTING

Some Typical Theodolite Diaphragms

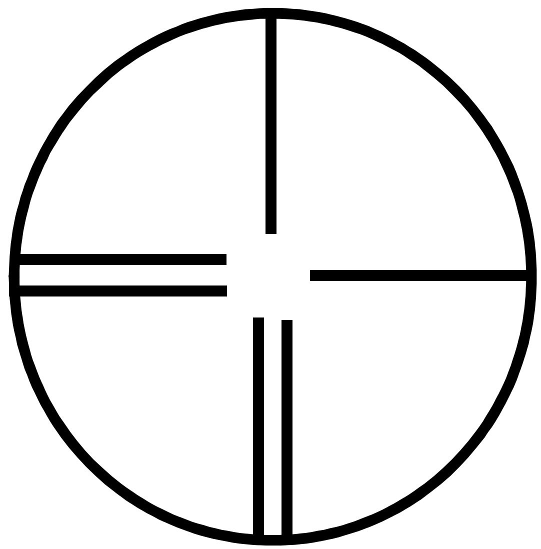


THEODOLITE SIGHTING

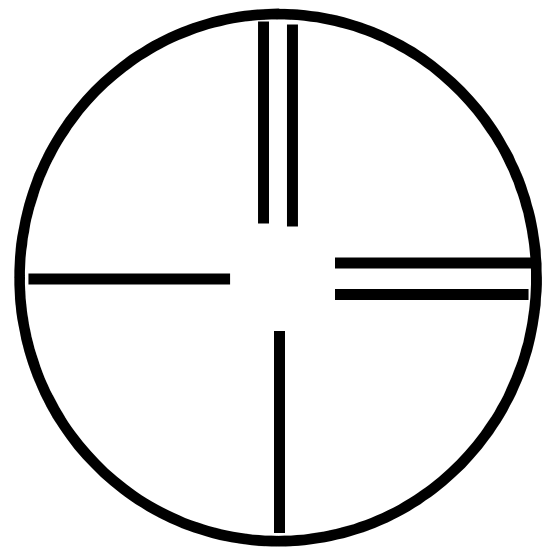
This is roughly what the diaphragm in our theodolites looks like



THEODOLITE SIGHTING

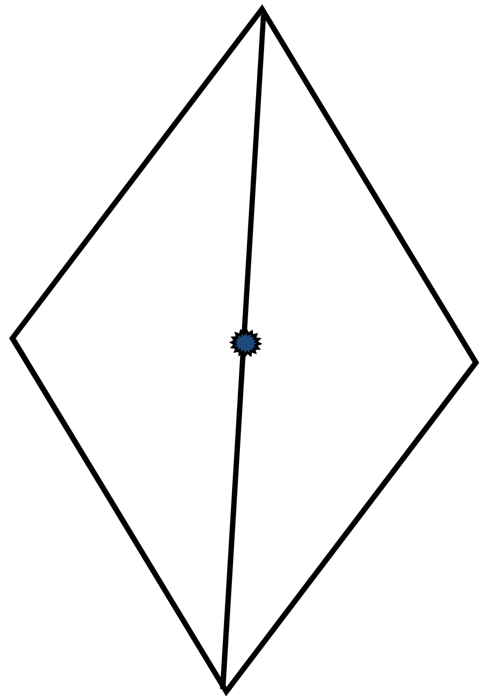


This is FACE LEFT

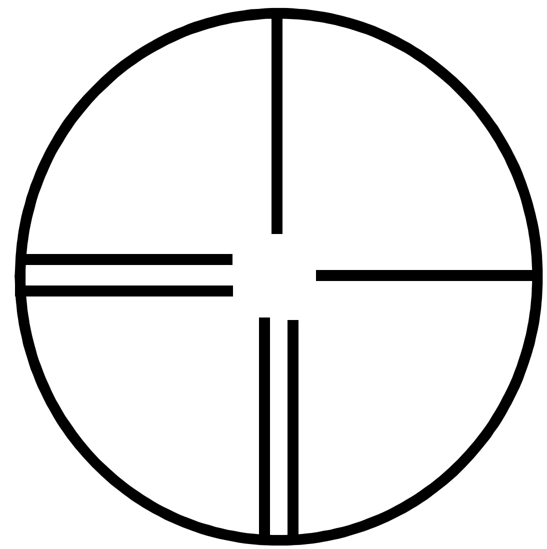


This is FACE RIGHT

THEODOLITE SIGHTING



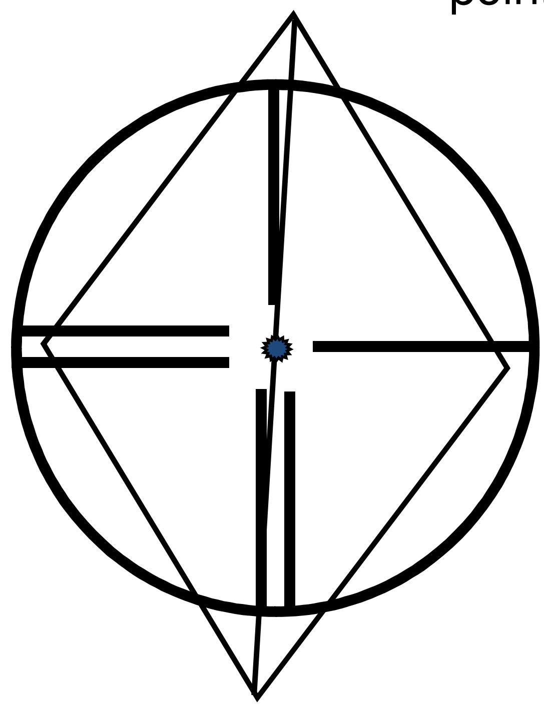
This is the sort of target that we have fixed to the wall outside.



We need to superimpose the theodolite diaphragm over the target

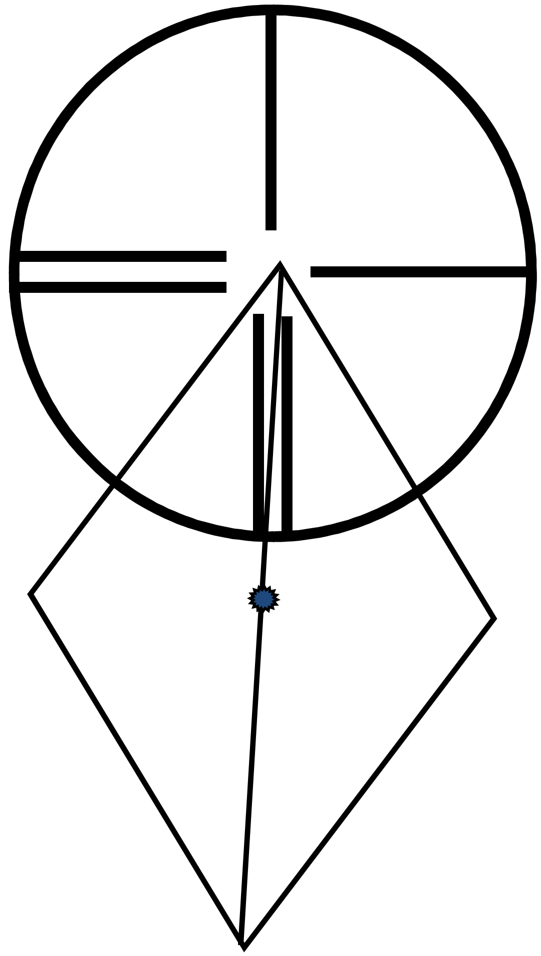
THEODOLITE SIGHTING

It is better to pick a well defined point such as the top point



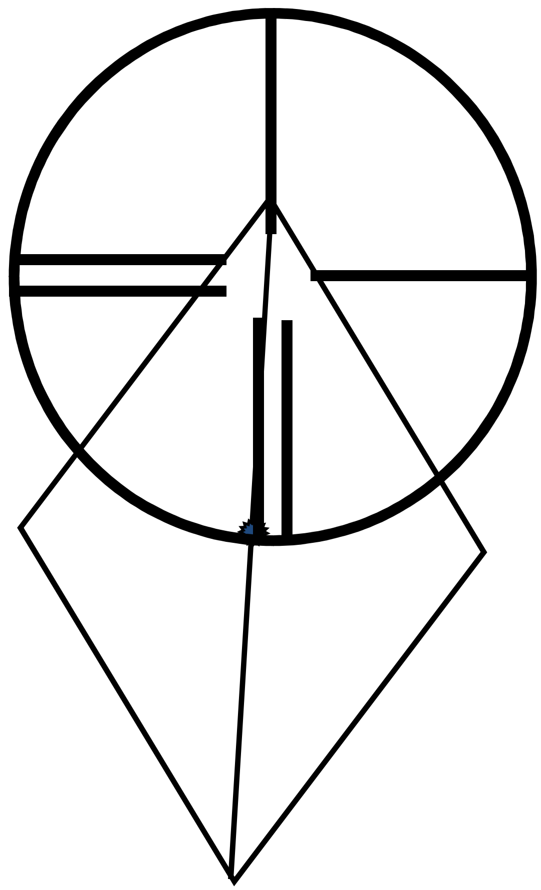
Going for the centre point is difficult particularly if the central line of the target is not vertical

THEODOLITE SIGHTING



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

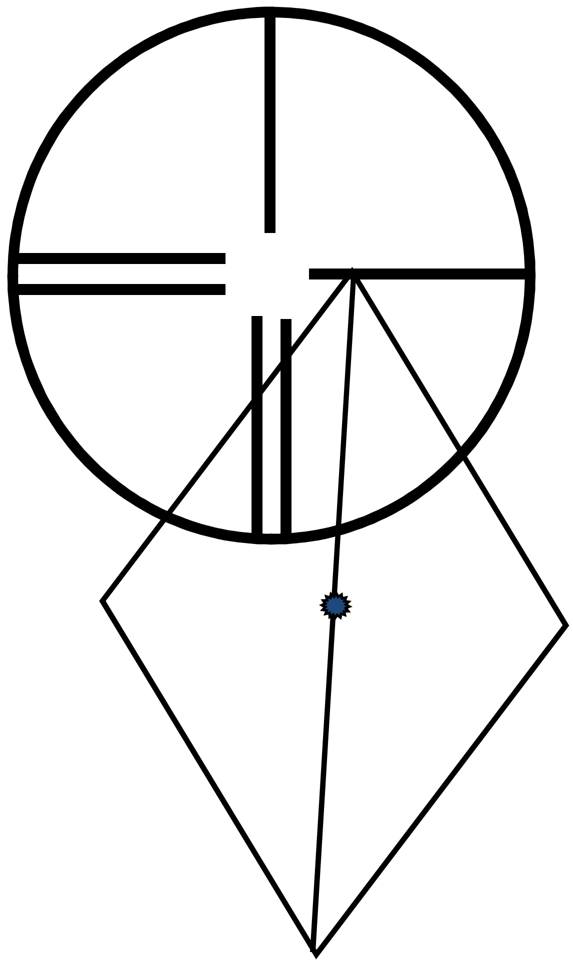
THEODOLITE SIGHTING



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** measurements

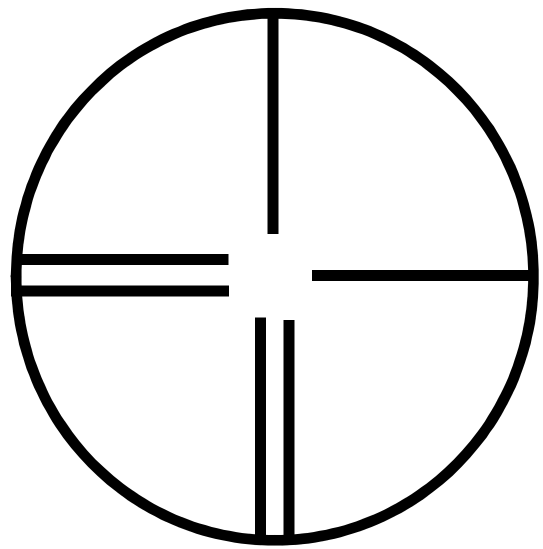
THEODOLITE SIGHTING



This is how we should sight a target for **vertical angle** measurements

THEODOLITE SIGHTING

Sometimes we use the single lines and sometimes it is better to use the double lines



EDM, TOTAL STATION, PRISM AND POLE

ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM)

- A major advance in surveying instrument occurred approximately 60 years ago with the development of electronic distance measurement (EDM) instruments. These devices measure lengths by indirectly determining the number of full and partial waves of transmitted, electromagnetic energy required in traveling between the two ends of a line. In practice, the energy is transmitted from one end of the line to the other and returned to the starting points

ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM)

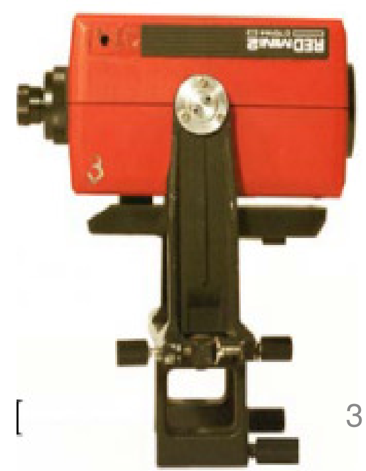
Definition

The electronic distance measurement instrument (EDM) is a relatively new development in the field of surveying. The instrument sends out a beam of light or high frequency microwaves from one end of line to be measured, and directs it towards the far end of the line. A reflector or transmitter receiver at the far end reflects the light or microwaves back to the instrument where they are analyzed electronically to give the distance between the two points

(Francis, 1982)

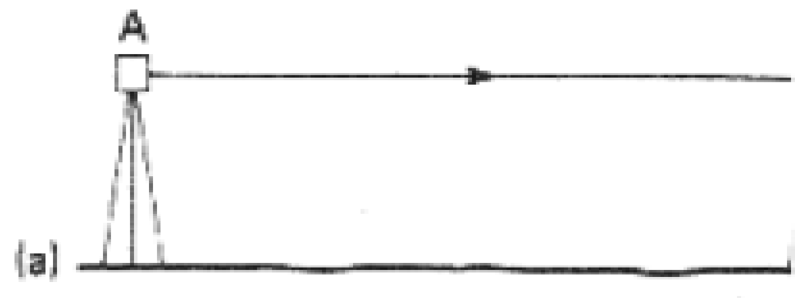
ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM)

EDM instruments are available to measure distance using light and radio waves. The distance is calculated either from the time difference between a transmitted pulse and a return pulse or the phase difference between a transmitted and a reflected beam of radiation



ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM)

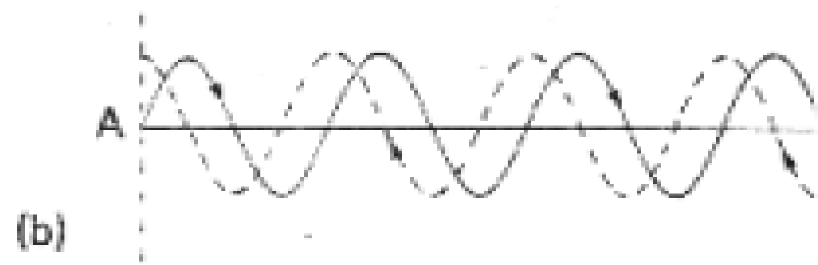
Components of EDM



- ❑ Light source
  - ✓ For transferring the electromagnetic waves

- ❑ Light Modulation
  - ✓ Change the light to Electromagnetic waves

- ❑ Phase Difference system



- ❑ Mini PC or Calculator

ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM)

Electromagnetic distance measuring equipment use three different wavelength bands:

EDM and electronic theodolite

- ❑ Microwave systems
  - ✓ Range up to 150 km
  - ✓ Wavelength 3 cm
  - ✓ Unaffected by visibility

- ❑ Light wave systems
  - ✓ Range up to 5 km
  - ✓ Visible light, lasers
  - ✓ 3-distance reduced by visibility

- ❑ Infra red systems
  - ✓ 1-Range up to 3 km
  - ✓ 2-limited to line of sight
  - ✓ 3-limited by rain, fog, and other airborne particles

- ❑ The accuracy of the measurement varies from type to type but is usually in the range from ±(1.0 mm + 1.0 ppm) to ±(10.0 mm + 5 ppm). EDM and electronic theodolite

ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM)

Advantages Some of the advantages of using an EDM are:

- a reduction in the time and crew size required for most measurements
- the ability to measure across traffic or construction operations without inconvenience to others (motorists or construction crews) or undue hazard to the survey crews
- the ability to measure otherwise inaccessible points, such as across deep canyons or rivers
- the ability to set many points from a relatively sparse control network, which is especially useful in construction staking
- the ability to measure with increased precision and consistency
- the ability to quickly establish better supplemental control for construction staking
- interface with a data collector

TOTAL STATION

A Total Station integrates the functions of a theodolite for measuring angles, an EDM for measuring distances, digital data and information recording. Examples of Total Stations are the Nikon DTM 801, Topcon and Geodimeter 400 series

- ❑ Examples of usage
  - ✓ General purpose angle and distance measurements.
  - ✓ Provision of control surveys, Contour and detail mapping, setting out and construction work

- ❑ Factors which influence the use of Total Stations
  - ✓ A clear line of sight between the instrument and the measured points is essential
  - ✓ A well defined measurement point or target/prism is required to obtain the maximum accuracy

TOTAL STATION

A total station is used for measuring both horizontal and zenith angles as well as slope distances. In addition, they also have features for measurement to points that cannot be directly observed (offset measurement) and basic Coordinate Geometry (COGO). At one time, total stations were classified as either directional or repeating instruments. Most total stations have the ability to make horizontal angular measurements using either the directional method or the repetition method.

Directional Method The horizontal circle remains fixed during a series of observations. The direction of each foresight is measured in relationship to the backsight. The mean horizontal angle is then equal to the average of all the individual angles.

Repetition Method Successive measurements of an angle can be accumulated. The mean angle is then equal to the sum of the total angle divided by the number of observations.

Procedures The directional method will be used exclusively for the control survey, ties to aerial photography control points (targets), property corners, right of way, property controlling corners and secondary control traverses. All horizontal angles will be measured clockwise (angle right) from the backsight regardless of the size of the angle.

TOTAL STATION INSTRUMENT

- An electronic digital theodolite and an electronic distance measurement in one integral unit

- They can automatically record horizontal and vertical angles and slope distances from a single setup

- Slope distance can be reduced to horizontal and vertical components instantaneously

- Given initial data they will display positions and elevations of sighted points

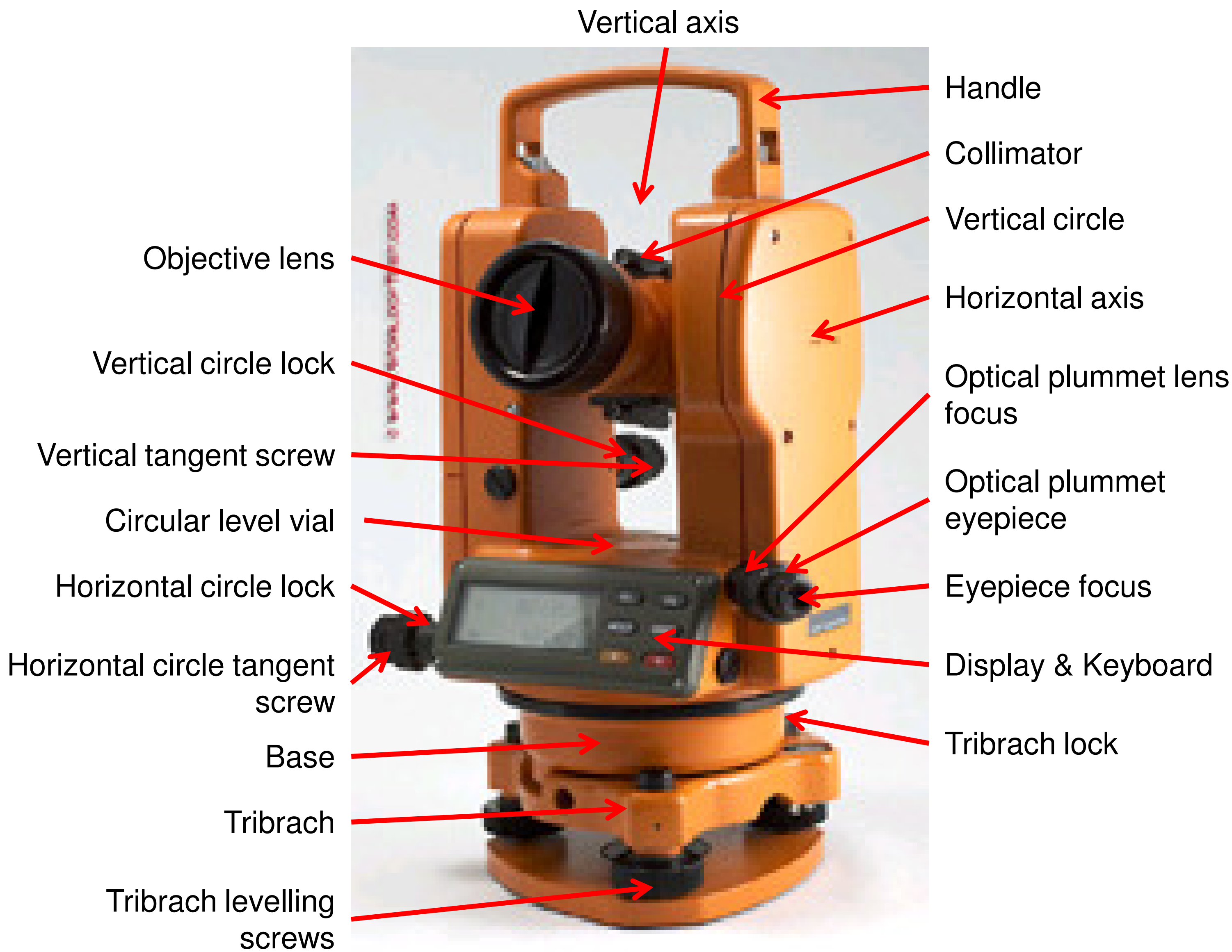
THREE BASIC COMPONENTS

- Total station instruments combine three basic components into one integral unit

  - ✓ An electronic distance measurement (EDM) instrument

  - ✓ An electronic angle measurement component

  - ✓ A computer or microprocessor


Vertical axis
Handle
Collimator
Vertical circle
Horizontal axis
Optical plummet lens focus
Optical plummet eyepiece
Eyepiece focus
Display & Keyboard
Tribrach lock
Objective lens
Vertical circle lock
Vertical tangent screw
Circular level vial
Horizontal circle lock
Horizontal circle tangent screw
Base
Tribrach
Tribrach levelling screws

FEATURES

- Automatically observe
  - ✓ Horizontal and vertical angles
  - ✓ Slope distances from a single set up

- Instantaneously compute
  - ✓ Horizontal and vertical distance components
  - ✓ Elevations
  - ✓ Coordinates of the point sighted

- Display the result on liquid crystal display (LCD)
  - ✓ Store the data, either on board or in external data collectors connected to their communication ports

FEATURES

- The EDM instruments that are integrated into the total station instruments, lengths up to about 4km which is adequate for most job

- Total station instruments are manufactured with two graduated circles, mounted in mutually perpendicular planes
  - ✓ Its horizontal circle is oriented in a horizontal plane, which automatically puts the vertical circle in a vertical plane
  - ✓ Horizontal and vertical angles can then be measured directly in their respective planes

- Averaging of multiple angles and distance measurements

- Correcting electronically measured distances for prism constants, atmospheric pressure and temperature

FEATURES

- Making curvature and refraction corrections to elevations determined by trigonometric levelling
- Reducing slope distances to their horizontal and vertical components
- Calculating point elevations from the vertical distance components (supplemented with keyboard input of instrument and refractor heights)
- Computing coordinates of surveyed points from horizontal angle and horizontal distance components (supplemented with keyboard input of coordinates for the occupied station and a reference azimuth)

TOTAL STATION SET UP

When total station is moved or transported, it must be in the case

- For most surveys, prior to observing distances and angles, the instrument must first be carefully set up over a specific point
- Establish tripod over the point
- Open the case and remove total station, placing it on the head of the tripod and attach securely with centre screw
- Close the case
- Grasp two tripod legs and look through the optical plumb, adjust the legs so that bulls eye is over the point (keep the tripod head as level as possible)
- Firmly place the legs of the tripod in the ground
- Mount the tribrach approximately in the middle of the tripod head to permit maximum translations in any direction

TOTAL STATION SET UP

- ❑ Utilizing the tripod leg adjustments, level the total station using the fish-eye bubble
- ❑ Loosen the centre screw to adjust the total station exactly over the point if needed
- ❑ Properly focus the optical plummet on the point
- ❑ Manipulate the levelling screws to aim the intersection of cross hairs of the optical plummet telescope at the point below
- ❑ Level the instrument using the plate bubble and levelling screws
- ❑ Loosen the centre screw to adjust the total station exactly over the point if needed
- ❑ Complete levelling the total station using level vial
- ❑ Check to make sure you are still on the point

Remember to charge the TOTAL STATION BATTERY for 6 hour before you start your work or check whether the total station is using AA BATTERY ?

LEVEL THE TOTAL STATION

- To level a total station instrument, the telescope is rotated to place the axis of the level vial parallel to the line through any two levelling screws, as the line through screw (A) and screw (B) in Figure (a) below
- The bubble is centred by turning these two screws, then rotated 90°, as shown in Figure (b), and centred again using the third screw (C) only
- The process is repeated and carefully checked to ensure that the bubble remains centred

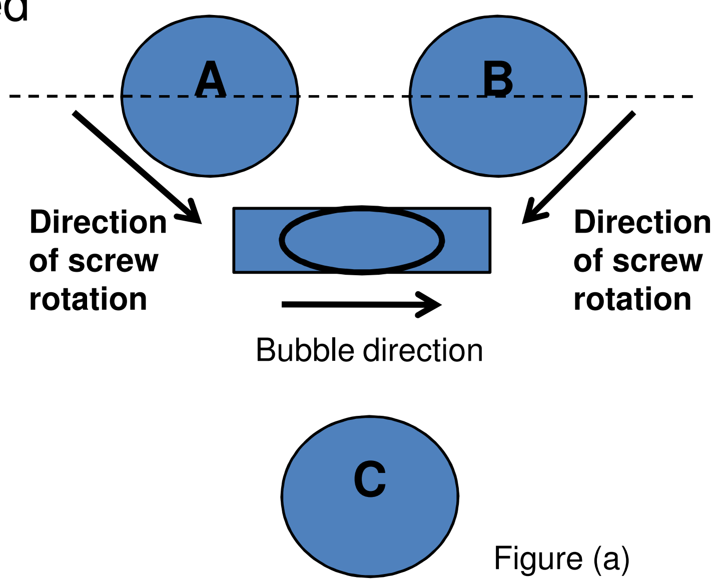


Figure (a)

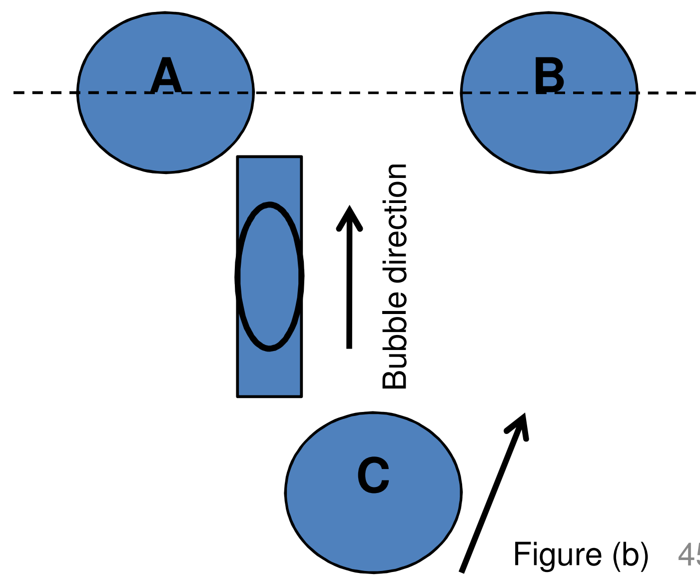
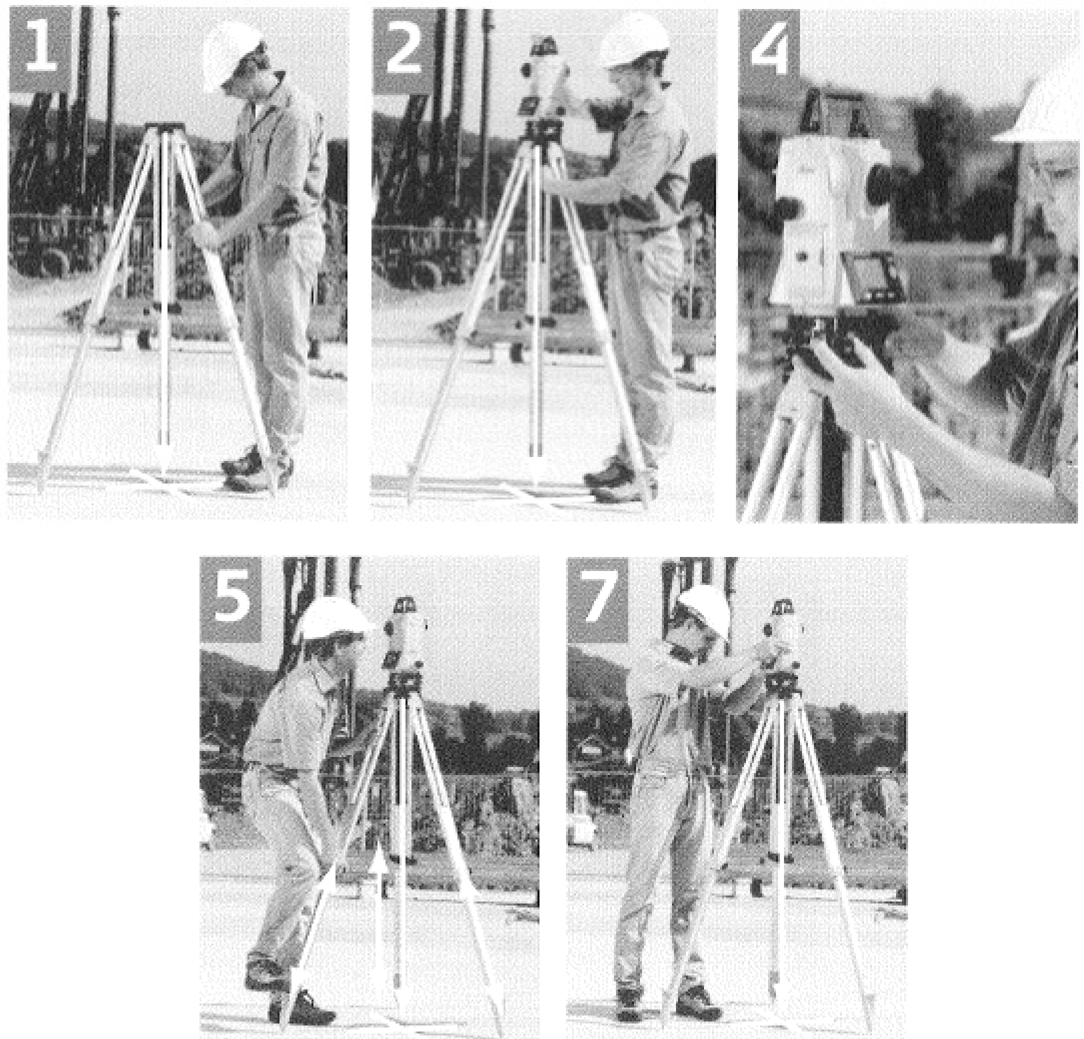


Figure (b)

SETTING UP A THEODOLITE/ TOTAL STATION



TURNING ANGLES WITH TOTAL STATION

- Sight on the backsight utilizing the horizontal adjustment screw
- Zero set the instrument (this provides an initial reading of 0 seconds)
- Loosen tangent screw and rotate instrument to foresight
- Tighten tangent screw and bring cross hair exact on target with adjustment screw
- Read and record angle as displayed
- To close the horizon:
  - ✓ Sight on foresight point from above and zero set instrument
  - ✓ Rotate to former backsight and adjust instrument to exact
  - ✓ Read and record angle as displayed
- Angle from direct and indirect should equal 360 degrees

TOTAL STATION DISTANCE MEASUREMENT

- Point the instrument at a prism (which is vertical over the point)
- Push the measure button and record the distance
- You can measure the horizontal distance or the slope distance, it is important that you note which is being collected
  - ✓ If you are measuring the slope distance, the zenith angle must be recorded to allow the horizontal distance to be computed
  - ✓ If you are collecting topographic data with elevations, it is important that the height of the instrument and the height of the prism be collected and recorded
  - ✓ This can also be solved by setting the prism height the same as the instrument height

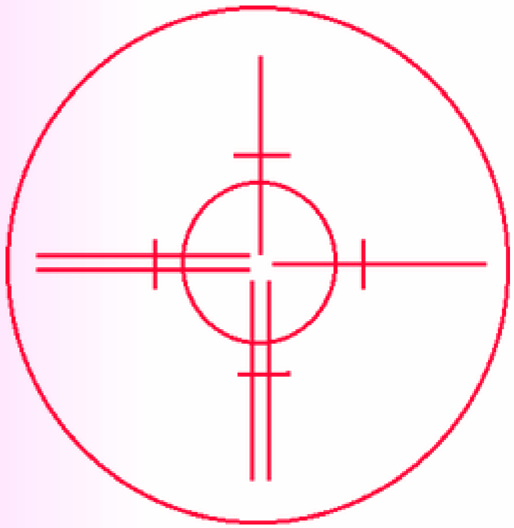
TOTAL STATION RULES

- When moving between setups in the field, proper care should be taken
- Before the total station is removed from the tripod, the food screw should be returned to the midpoints of the posts
- The instrument should never be transported on the tripod
- With adjustable leg tripods, stress on the legs can be avoided by retracting them to their shortest positions and lightly clamping them in position
- When returning the total station to its case, all locking mechanisms should be released
- If the instrument is wet, it should be wiped down and left in an open case it is dry

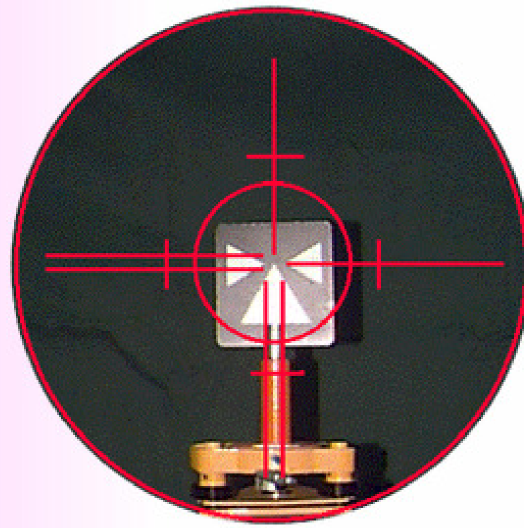
TOTAL STATION RULES

- Never point the instrument at the sun, this can damage the components of the instrument as well as cause immediate blindness
- Never move or transport the total station unless it is in the case provided
- Do not attempt to rotate the instrument unless the tangent screw is loose
- Avoid getting the instrument wet, if it does get wet, wipe it down and allow to dry in a safe area before storage
- Batteries of the total station must be charged regularly. At least once per month, the battery should be cycled
- Care should be taken at all times, these units are expensive ($8,000 - $45,000)

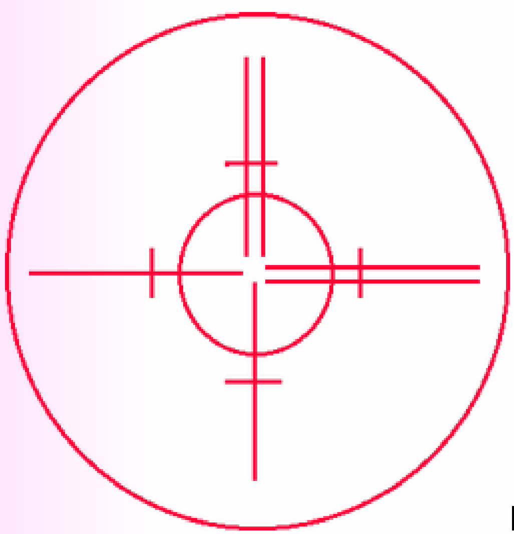
TOTAL STATION SIGHTING



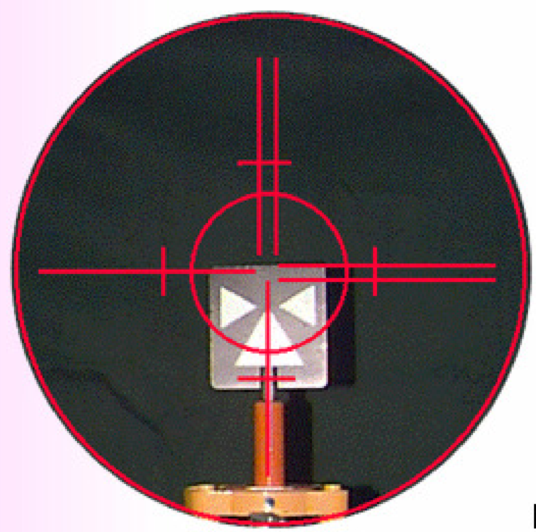
Face Left



Wrong

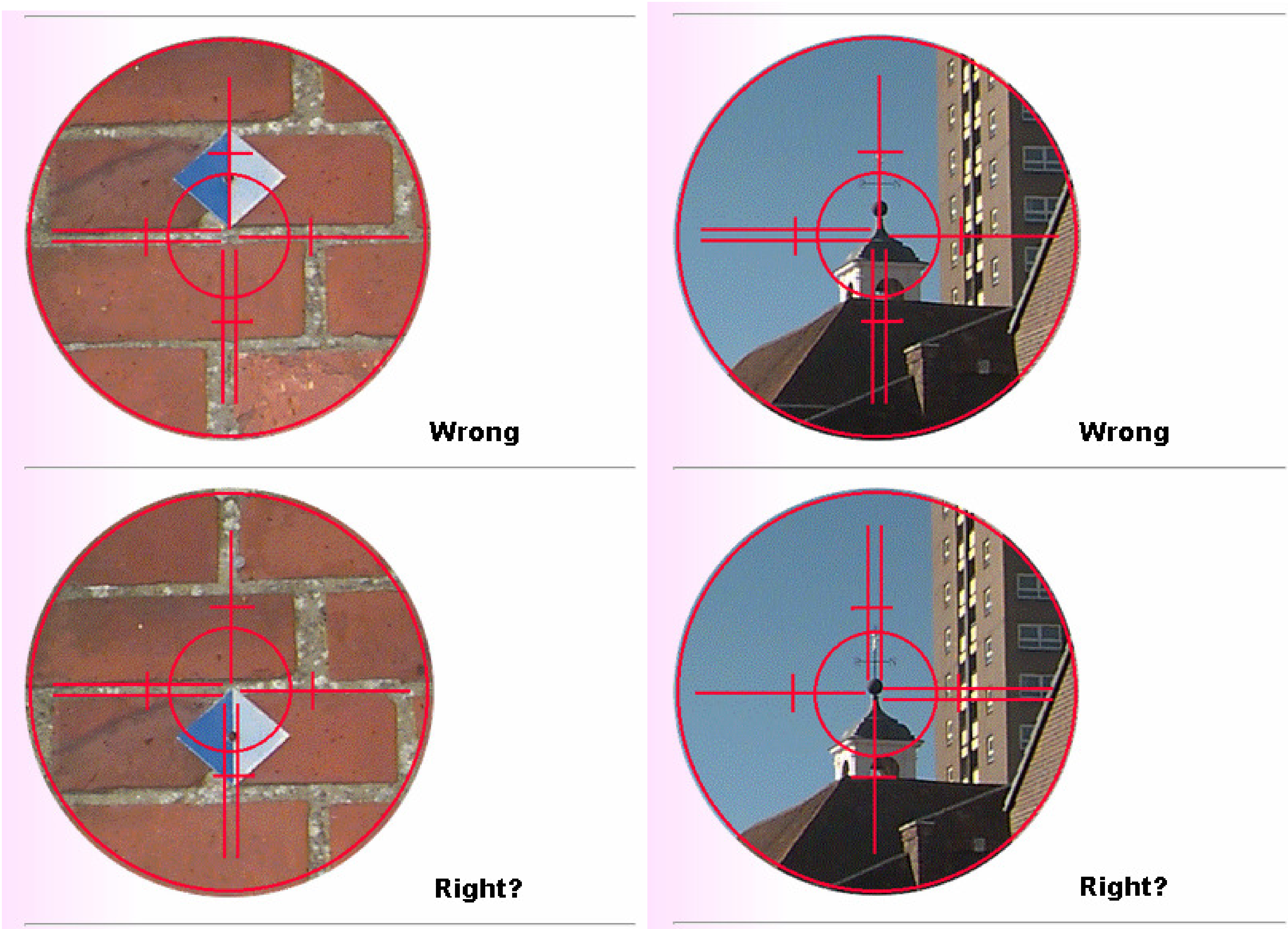


Face Right



Right

TOTAL STATION SIGHTING



THEODOLITE - INSTRUMENT CHECKS

There are 6 possible instrument errors:

1) Plate Bubble Error . This is checked every time the theodolite is set up. i.e. check the bubble drift in positions c) and d) and then eliminate the error by “ Freezing the Bubble”

2) Non - Vertical Cross Hairs . Move the telescope up and down while sighting a well defined distant point. Any error will be very obvious

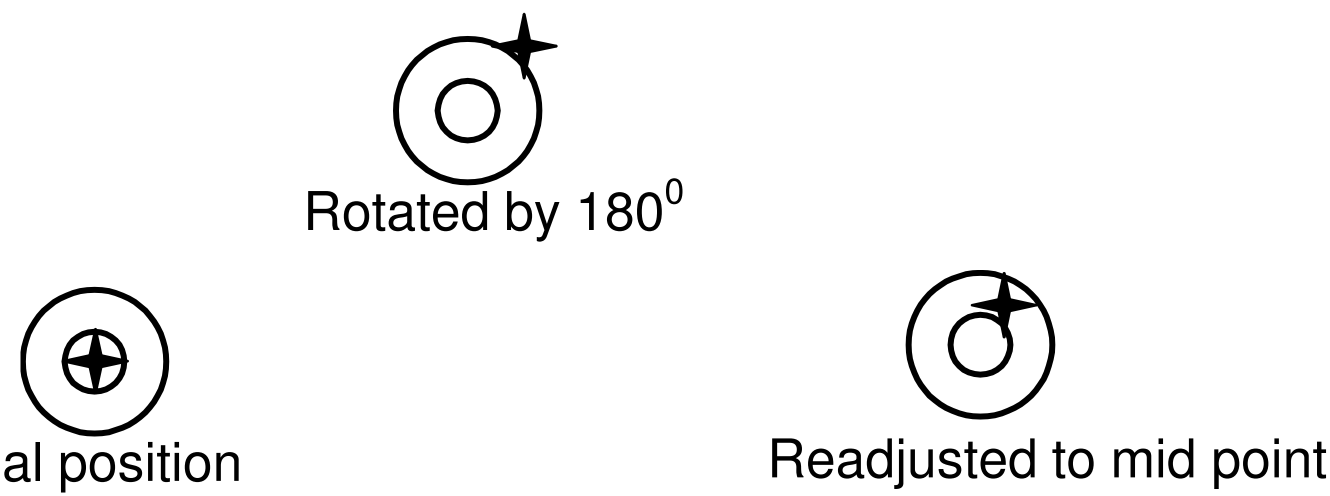
3) Horizontal Collimation Error . Sight a well defined point and read the horizontal circle on F/L and F/R. The difference in the minutes and seconds should be <40”

4) Trunnion Axis Dislevelment . Spire Test. Sight a well defined elevated point (church spire) then lower the telescope onto a tape or staff about 40m away. The difference between F/L and F/R should be < 5mm for most engineering applications

THEODOLITE - INSTRUMENT CHECKS

5) Vertical Collimation Error . Sight a well defined point and read the vertical circle on F/L and F/R. The difference in the minutes and seconds should be <40”

6) Laser Plumb Error . Check the laser plumb alignment in two positions 180° different



TRIBRACHS

A tribrach is the detachable base of all total stations, and they are also used to attach prisms to a tripod. A Department tribrach is equipped with a bull's-eye bubble (circular level) and optical plummet.

Special Care The tribrach is an integral part of the precision equipment and should be handled accordingly. It should be transported in a separate compartment or other container to prevent damage to the base surfaces, bull's-eye level and optical plummet eyepiece. Over-tightening of the tripod fastener screw can put undue pressure on the leveling plate.

Adjustments An out-of-adjustment tribrach will cause centering errors. Each tribrach should be routinely checked for centering. Using a plumb bob is quick method for checking if the tribrach is out of adjustment. To perform this task, center the instrument over the point using the plumb bob, remove the plumb bob and check the centering using the optical plummet. If the error exceeds 0.01 ft (0.003m) use one of the following methods to correct the centering error.

TRIBRACHS

One field method used to adjust for centering errors is to mark and rotate the tribrach 120 degrees at a time on a tripod. Before adjusting the optical plummet, adjust the bull's-eye bubble by using the instrument plate level bubble. For the first sighting, draw a line with a soft pencil on the tribrach head around the tribrach base. Carefully level the tribrach and mark the sighting point on the ground using the optical plummet. Then rotate the tribrach 120 degrees, carefully set it in the pencil marks, re-level it and mark the new sighting point. Then rotate a third time and repeat the procedure. If the tribrach is out of adjustment, the three rotational marks should form a triangle. Adjust the optical plummet to the center of the triangle using the capstan screws. Repeat the test to verify the adjustment triangle is minimized.

TRIBRACHS

A tribrach-adjusting ring is the preferred method. Place a tribrach on a tripod and the adjusting ring in the tribrach. Place the tribrach to be adjusted upside down on the ring. Look through the optical plummet and pick out a well-defined point on the ceiling. Turn the leveling screw on the bottom tribrach to center the optical plummet on the selected point on the ceiling. Rotate the top tribrach on the ring 180 degrees. If the cross hair stays on the point when rotated, the optical plummet is in adjustment. If not, use the leveling screws on the bottom tribrach to eliminate one half of the error. Eliminate the remaining error with the adjusting screws on the optical plummet. Repeat the procedure until the cross hair rotates on the point. The tribrach does not have to be level to perform the adjustment.

When adjusting the optical plummet, slightly loosen the appropriate capstan screw and equally tighten the opposite capstan screw. Use caution when tightening the capstan screws since they can easily be twisted off. Refer to the instrument user manual for detailed instructions.

PRISM

- A corner-cube or reflective prism is essential for most Total Stations and EDM. The prism is used to return the transmitted beam to the instrument to allow a distance to be determined by time of flight or phase comparison

- Total stations allow for the direct input of temperature and pressure and automatic application of meteorological corrections. Most of the current EDM instruments use LASER beams and reflectors

- The latest models provide for reflector-less measurements, thus improving efficiency for certain applications drastically

ROUTINE CARE OF THEODOLITE/TOTAL STATION

Special Care Although total stations are ruggedly built, careless or rough use and unnecessary exposure to the elements can seriously damage the instruments. If they are handled reasonably, the instruments will provide consistently good results with a minimum of down time for repair or adjustment. Some general guidelines for the care of instruments are:

- Transport and store instruments in positions that are consistent with their carrying case design. Protect the instruments from excessive vibrations by carrying them in their shipping cases.
- Instruments should be removed from the case with both hands. Generally, instruments are equipped with a carrying handle; use one hand to grip the handle and the other to support the base. Use one hand to continually support the instrument until the tribrach lock is engaged or the tripod fixing screw is secured.
- In most cases, total stations and other instruments should be removed and re-cased for transportation to a new point. If the instrument has a carrying handle, you can use the handle for walking the instrument between set-ups; however, it is recommended to case the instrument for transportation.
- The instrument should not be placed on the ground since dust or dirt can accumulate on the threads and the base plate.
- As feasible, protect the instrument from moisture.
- Never carry the instrument on the tripod.
- Turn the instrument off prior to removing the battery.
- Remove the battery from the instrument before the instrument is placed in its carrying case.
- Never use a total station for a solar observation unless an approved solar filter is used. This will destroy an element in the EDM, plus damaging the eye of the observer.

ROUTINE CARE OF THEODOLITE/TOTAL STATION

- Before making the first set up of the day, visually inspect the instrument for damage. Check the machined surfaces and the polished faces of the lenses and mirrors. Try the clamps and motions for smooth operation

- Clean the exterior of the instrument frequently. Any accumulation of dirt and dust can scratch the machined or polished surfaces and cause friction or sticking in the motions. Remove dirt and dust with a clean, soft cloth or with a brush. Clean non-optical parts with a soft cloth or clean chamois

- Clean the external surfaces of lenses with a fine lens brush and, if necessary, use a dry lens tissue. Do not use silicone-treated tissues because they can damage coated optics. The lens may be moistened before wiping it, but do not use liquids for cleaning. Do not loosen or attempt to clean the internal surfaces of any lens

- After an instrument has been used in damp or cold situation, use special precautions to prevent condensation of moisture inside the instrument. If the instrument is used in cold weather, leave it in the carrying case in the vehicle during non-working periods rather take it into a heated room. If you store the instrument in a heated room overnight, remove it from the carrying case. If the instrument is wet, bring it into a warm, dry room, remove it from its case and leave it at room temperature to dry it

VEHICULAR TRANSPORT

- Transport and store instrument in positions that are consistent with the carrying case design. For example, total station should be carried and stored in their correct position. Many instrument cases indicate the position in which they should be transported

- Treat tribrachs, prism and tripods with care. Carry them in their shipping cases or cushion them with firm polyfoam or excelsior-filled cases to protect the from jolting or vibrating excessively

CASING AND UNCASING

Before removing an instrument, study the way it is placed and secured in the case. Place it in the same position when you return it to the case. In removing the instrument from the case, carefully grip it with both hands, but do not grip the vertical circle standard or where pressure will be exerted or tubular or circular level vials

SOURCES OF ERROR IN TOTAL STATION WORK

- Instrument Errors

  - ✓ Plate bubble out of adjustment
  - ✓ Horizontal axis not perpendicular to vertical axis
  - ✓ Axis of sight not perpendicular to horizontal axis
  - ✓ Vertical circular index error
  - ✓ Eccentricity of centres
  - ✓ Circle graduation errors
  - ✓ Errors caused by peripheral equipment

SOURCES OF ERROR IN TOTAL STATION WORK

- Natural Errors
  - ✓ Wind
  - ✓ Temperature effects
  - ✓ Refraction
  - ✓ Tripod settlement

SOURCES OF ERROR IN TOTAL STATION WORK

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

MISTAKES

- Some common mistakes in angle measurement work are:

  - ✓ Sighting on, or setting up over the wrong point
  - ✓ Calling out or recording an incorrect value
  - ✓ Improper focusing of the eyepiece and objective lenses of the instrument
  - ✓ Partiality on the tripod, or placing a hand on the instrument when pointing or taking readings

Thank You & Question and Answer