GEO-A-CC-2-04-TH/PH – Thematic Mapping and Surveying

Basic concepts of surveying and survey equipment: Dumpy level

MANAS PAUL

ASSISTANT PROFESSOR

RAMMOHAN COLLEGE, KOLKATA

Level line

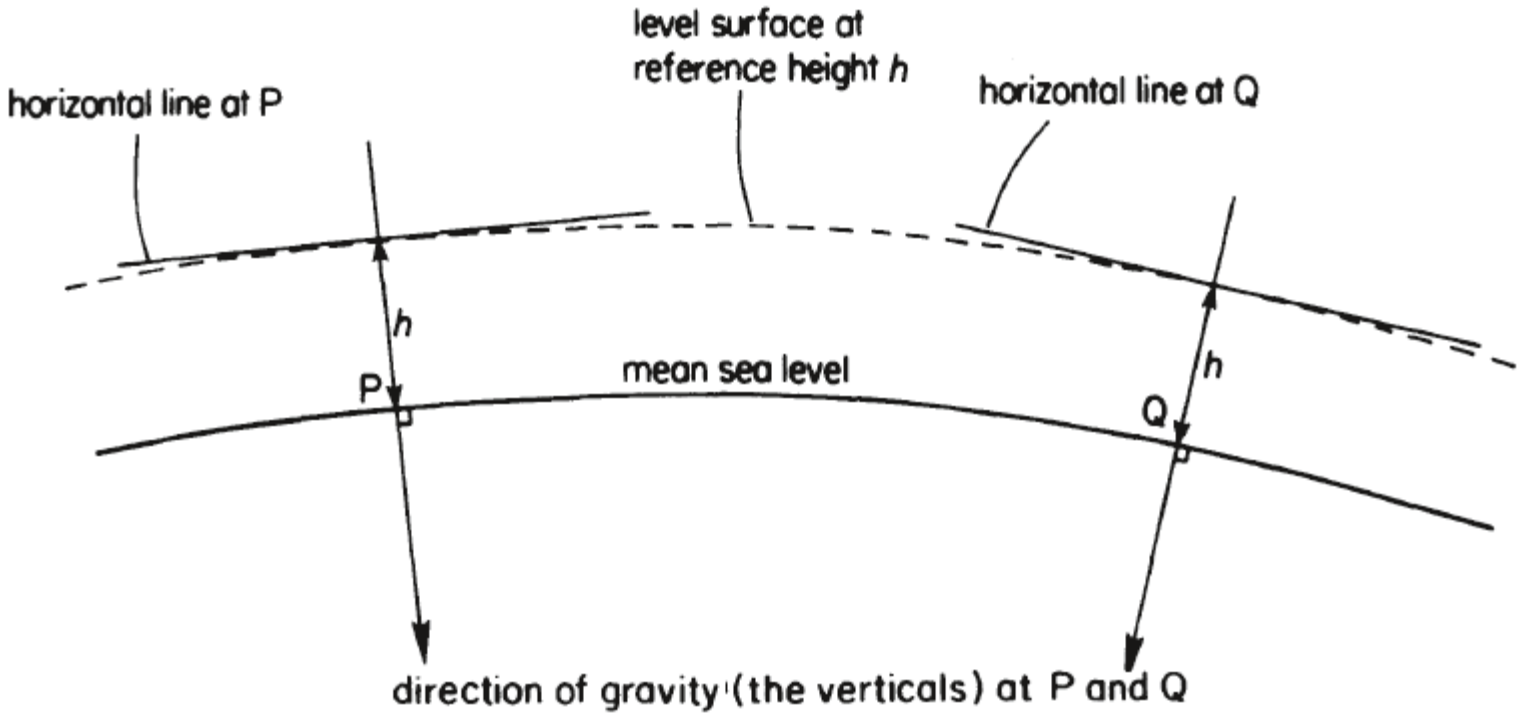
- When levelling, the heights of points on the Earth's surface are determined and these must all be based on the same reference height for consistency. Such a reference height is a *level line* or *level surface* and is defined as a surface on which all points are normal to the direction of gravity as defined by a suspended plumb bob.
- Since the surface of the Earth is curved, level surfaces are also curved.

Horizontal line

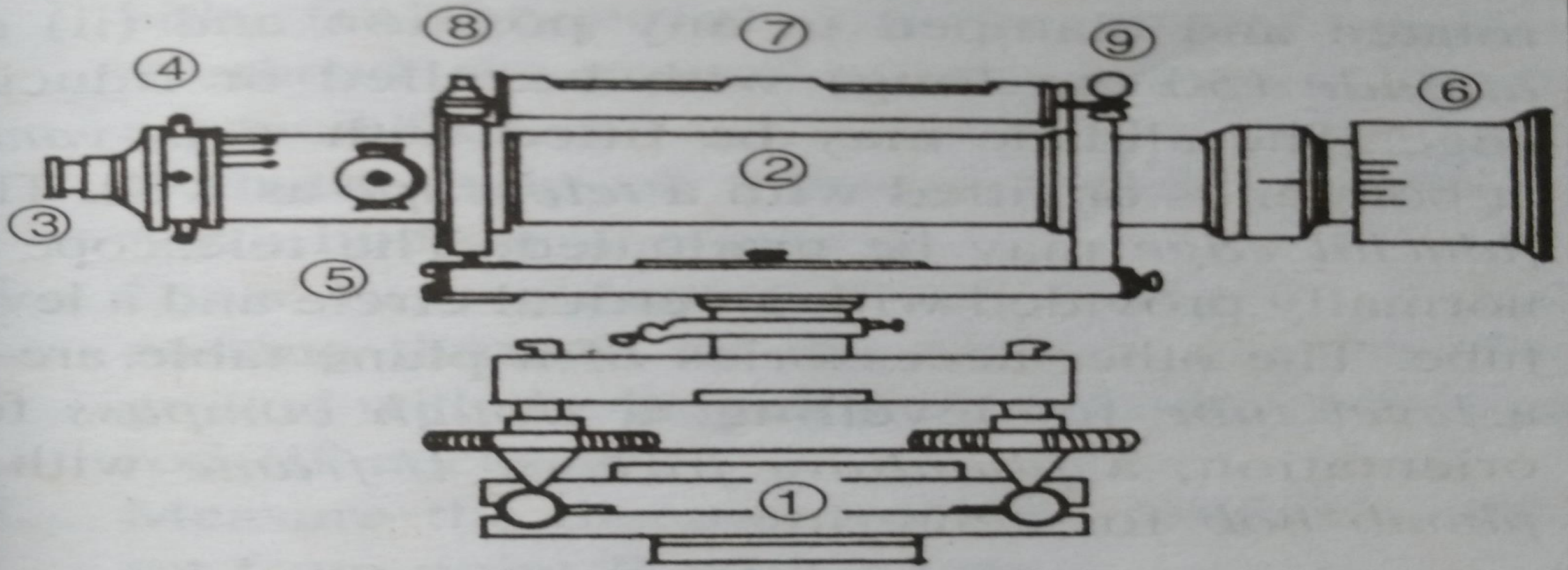
- A *horizontal line* is one which is normal to the direction of gravity at a particular point and is, therefore , tangential to the level surface at each point chosen.
- The difference between a horizontal line and a level line is called *curvature*

Datum

In levelling operations, a level line is chosen to which the elevation of all points is related and is known as a *datum* or *datum surface.* This can be any surface but the most commonly used datum is *mean sea level.*



Level and horizontal lines



1. Levelling head 2. Telescope 3. Eye-piece
4. Diaphragm 5. Focussing screw 6. Ray-shade
7. Level tube 8. Level tube nuts 9. Cross bubble tube

Fig. 3.14 Dumpy Level

Diaphagm

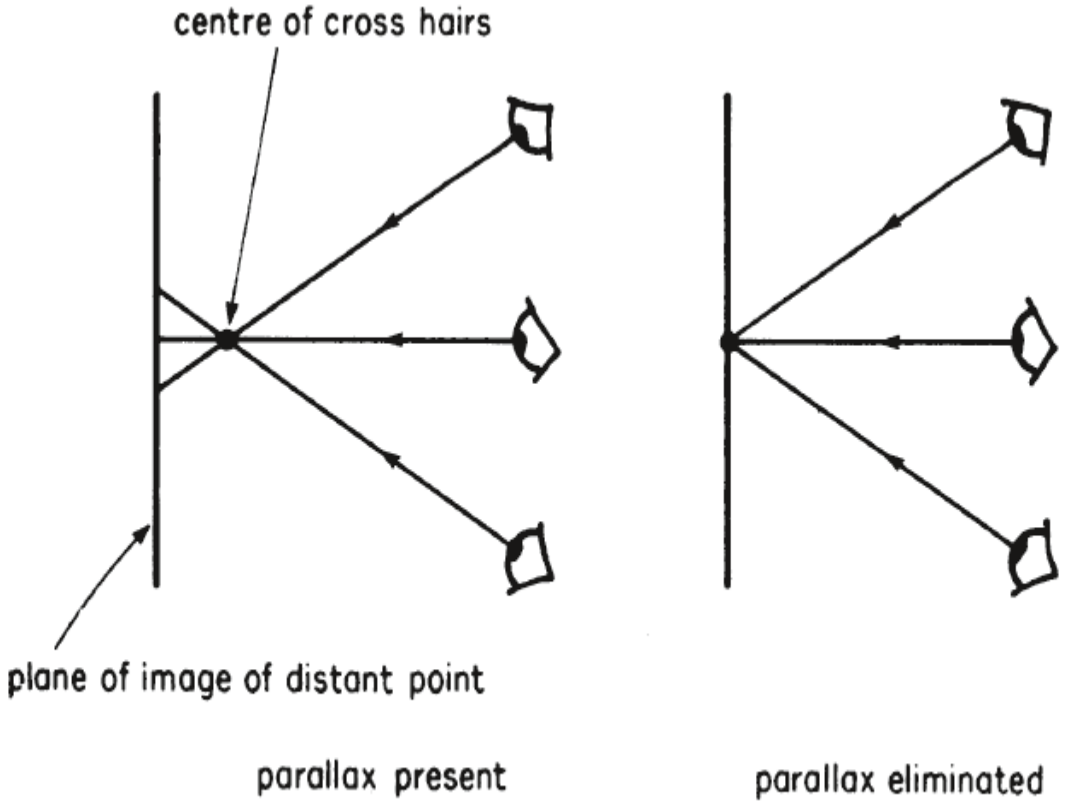
- The surveying telescope is *internally focusing*. Incorporated in the design of the telescope are special cross lines which, when the telescope is adjusted correctly, are seen clearly in the field of view. These lines provide a reference against which measurements can be taken. This part of the telescope is called the *diaphragm* and consists of a circle of plane glass upon which a series of lines is etched.
- The vertical and horizontal lines are called the *cross hairs.*
- The object lens, focusing lens , diaphragm and eyepiece are all mounted on the same optical axis and the imaginary line passing through the centre of the cross hairs and the optical centre of the object lens is called the *line of collimation* or the *line of sight .* When using the level, all readings are taken using this line .

Parallax

- For the surveying telescope to operate correctly the image of a distant point or object must fall exactly in the plane of the diaphragm and the eyepiece must be adjusted so that its focal point is also in the plane of the diaphragm .
- Failure to achieve either of these settings results in a condition called *parallax* and this is a major cause of error in both levelling.
- Parallax can be detected by moving the eye to different parts of the eyepiece when viewing a distant object; if different parts of the object appear against the cross hairs then the telescope has not been properly focused and parallax is present.

Remove parallax

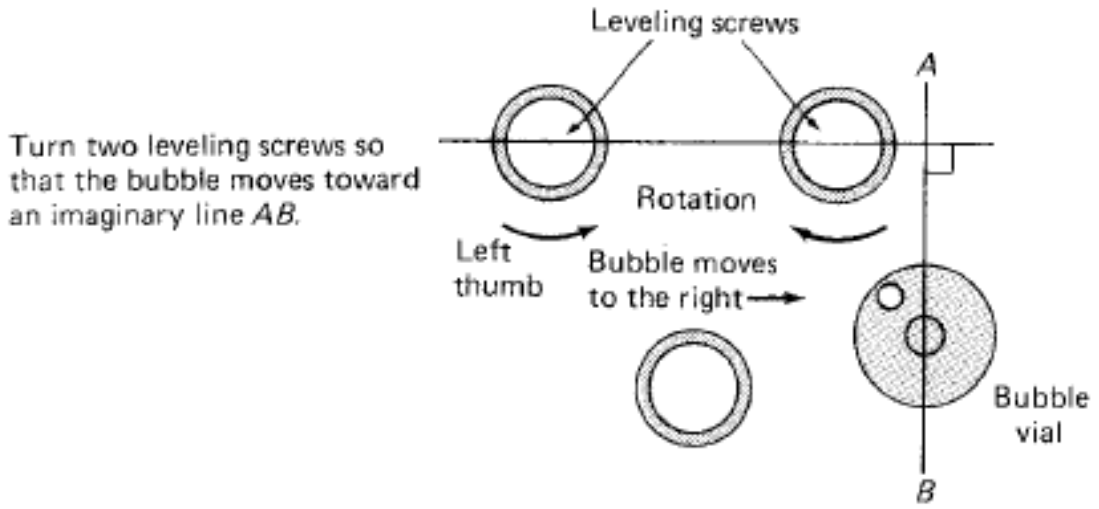
- To remove parallax , the eyepiece is first adjusted while viewing a light background , for example, the sky or a booking sheet, until the cross hairs appear in sharp focus. The distant point at which readings are required is now sighted and brought into focus and is viewed while moving the eye. If the object and cross hairs do not move relative to each other then parallax has been eliminated.



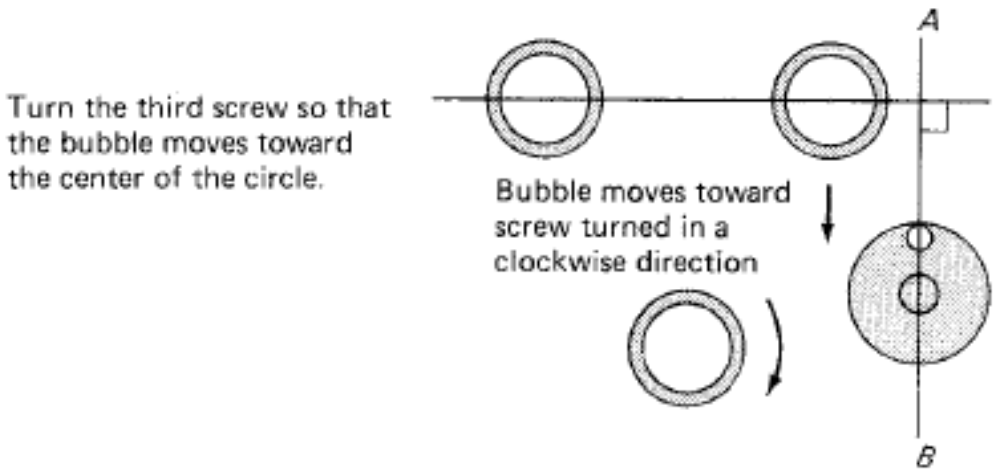
Defects in lense

- Chromatic aberration
- Spherical aberration

Temporary adjustment of spirit level



(a)



Procedure in levelling

- Rise and fall method
- Height of collimation method

Relative advantage

- The rise and fall method, although it involves more arithmetic, is preferred since it checks all the reduced level calculations whereas the collimation method does not check the calculations of the intermediate reduced levels.
- However, the collimation method is quicker where a lot of intermediate sights have been taken since fewer calculations are required and it is a good method to use when setting out levels where, usually, many readings are taken from each instrument position .

Errors in Levelling (continued)

- *Tripod defects:* The stability of tripods should be checked before any fieldwork commences by testing to see if the tripod head is secure, that the metal shoes at the base of each leg are not loose and that, once extended, the legs can be tightened sufficiently. When fitted, the wing nuts must be tightened before readings are taken.

2. *Field Errors*

- *Staff not vertical:* failure to hold the staff vertical will result in incorrect readings. The staff is held vertical with the aid of periscope-type handles and a pond bubble.
- *Unstable ground:* When the instrument is set up on soft ground and bituminous surfaces on hot days, an effect often overlooked is that the tripod legs may sink into the ground or rise slightly. Readings are taken in quick succession.

Errors in Levelling (continued)

- *Handling the instrument and tripod:* When levelling, avoid contact with the tripod and only use the level by light contact through the fingertips. If at any stage the tripod is disturbed, it will be necessary to relevel the instrument and to repeat all the readings taken from that instrument position.
- *Instrument not level:* The best procedure here is to ensure that the main bubble is centralised before and after a reading is taken.

3. *Reading and Booking Errors: i)* difficulty of reading an inverted staff image, ii) sighting the staff over too long a distance, iii) may be increased to a maximum of 100 m.

4. Effects of Curvature and Refraction on Levelling

5. Weather Conditions

Summary of the Levelling Fieldwork

When levelling, the following practice should be adhered to if many of the sources of error are to be avoided.

(I) Levelling should always start and finish at points of known reduced level so that misclosures can be detected. When only one bench mark is available, levelling lines must be run in loops starting and finishing at the bench mark.

(2) Where possible, all sight lengths should be below 60 m.

(3) The staff must be held vertically by suitable use of a pond bubble or by rocking the staff and noting the minimum reading.

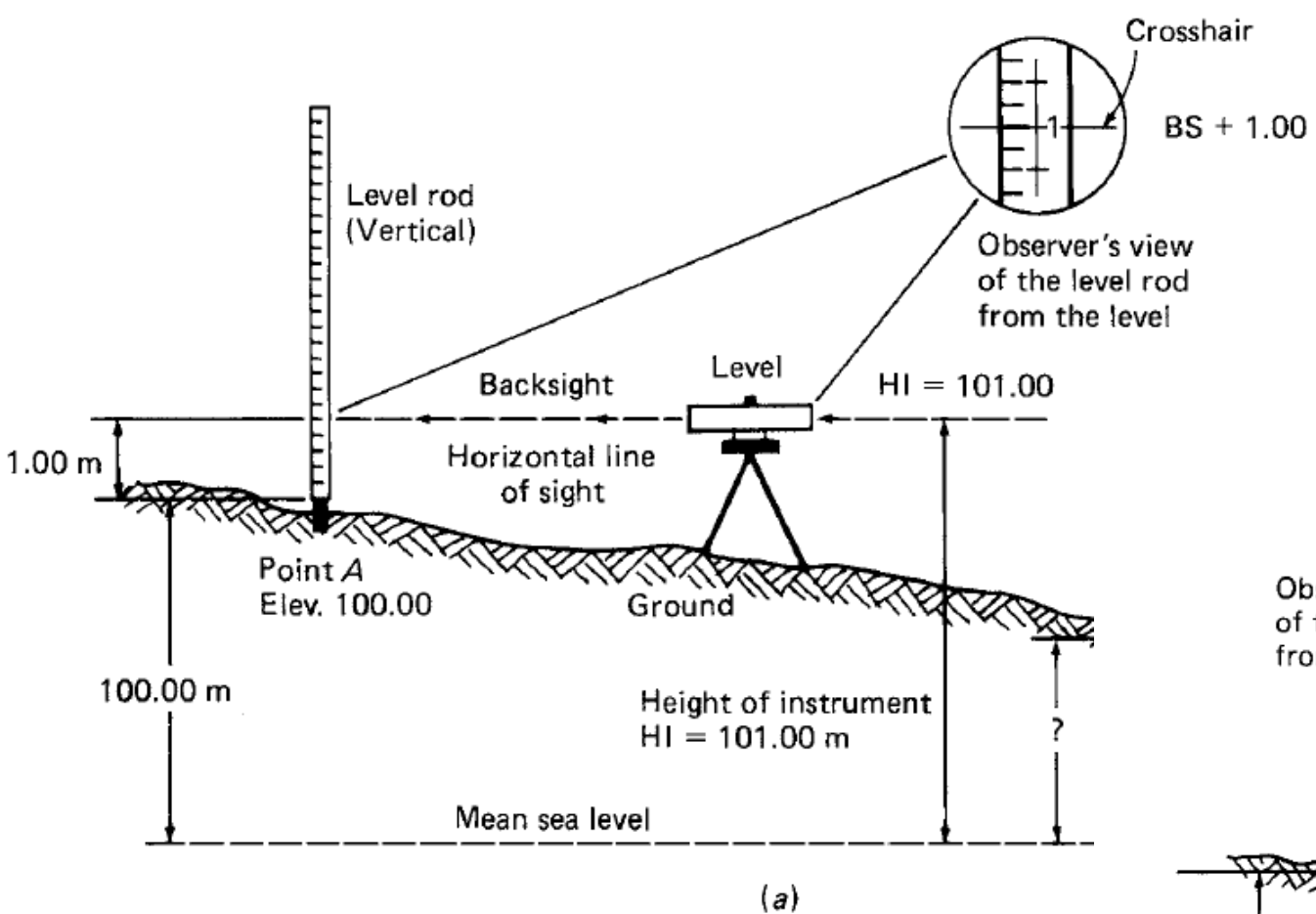
(4) BS and FS lengths should be kept equal for each instrument position. For engineering applications, many IS readings may be taken from each set-up. Under these circumstances it is important that the level has no more than a small collimation error.

(5) Readings should be booked immediately after they are observed and important readings, particularly at change points, should be checked .

SOURCES OF ERROR

- (1) The main source of error is the residual collimation error of the instrument. From the two-peg test it should be apparent that this error would be eliminated by equalizing the lengths of the BS and FS. This could be done quite adequately by using the stadia hairs of the level, as in tacheometry, although in simple levelling balancing of the lengths of sights is not always possible. Theoretically equalization of the sums of the lengths of BS and FS will eliminate collimation error, but variations in focusing may affect this.
- (2) Staff not held vertical; eliminated by fitting a spirit bubble to the staff, or by swaying the staff backwards and forwards in the direction of the level until a minimum reading is obtained.
- (3) Error in reading staff; minimized by reducing the length of sight so that readings are easily defined.

- (4) Mistake in reading staff, such as reading '6' for '9'; have the booker read figures back and check them. May also be used to reduce booking error.
- (5) Staff moving off position at CP when turned to face the new instrument setting; use a levelling plate on soft ground, and clearly mark the CP on hard ground.
- (6) Instrument settlement; set up on firm ground, dig tripod legs well into the ground and avoid excessive movement about instrument.
- (7) Errors due to refraction from warm layers of air at ground level; keep readings at least 1 m above ground.
- (8) Errors due to staff not being fully extended. This may be due either to carelessness on the staff-holder's part or to wear on the joints or retaining spring.
- (9) Finally, it is important to eliminate parallax in the instrument by bringing the crosshair into sharp focus using the eye-piece focusing screw.



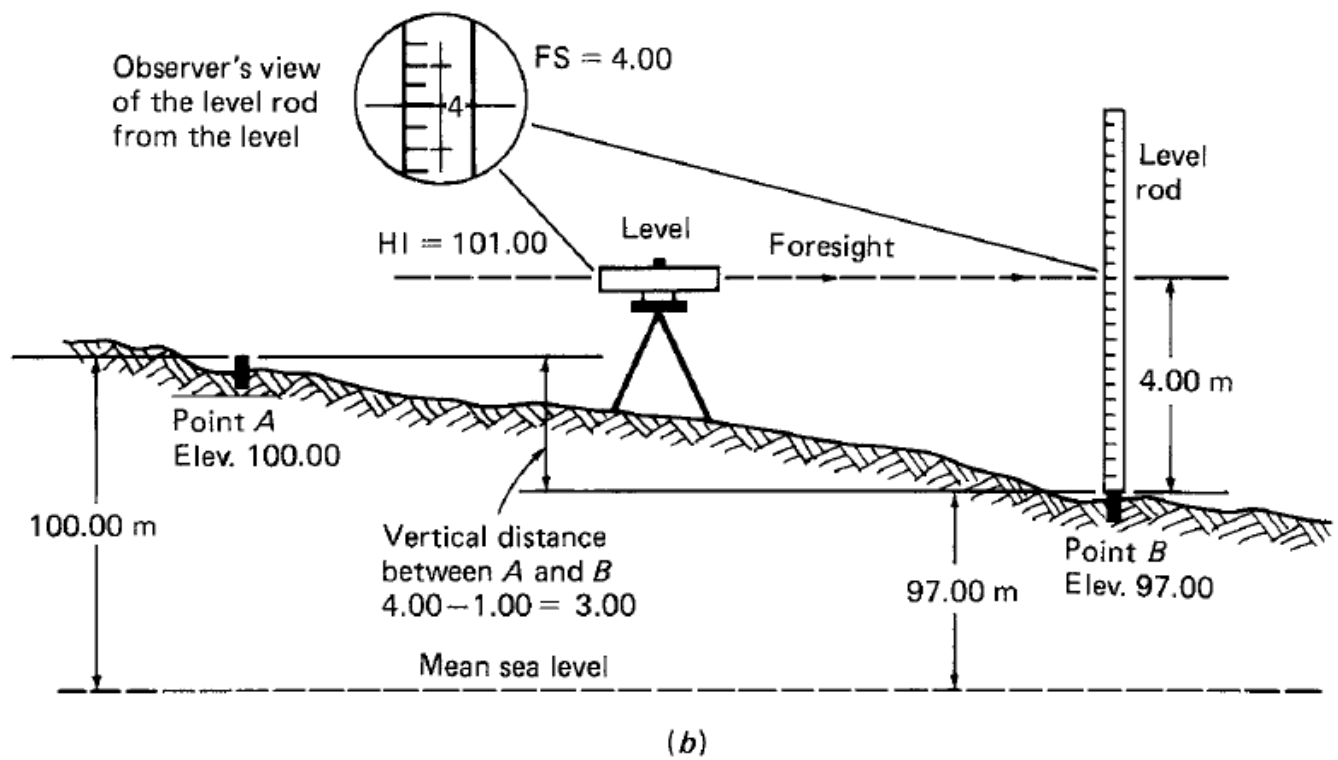


FIGURE 5-1. Differential leveling to measure vertical distance and elevation. (*a*) Step 1: Take a backsight rod reading on point *A*. (*b*) Step 2: Rotate the telescope toward point *B* and take a foresight rod reading.

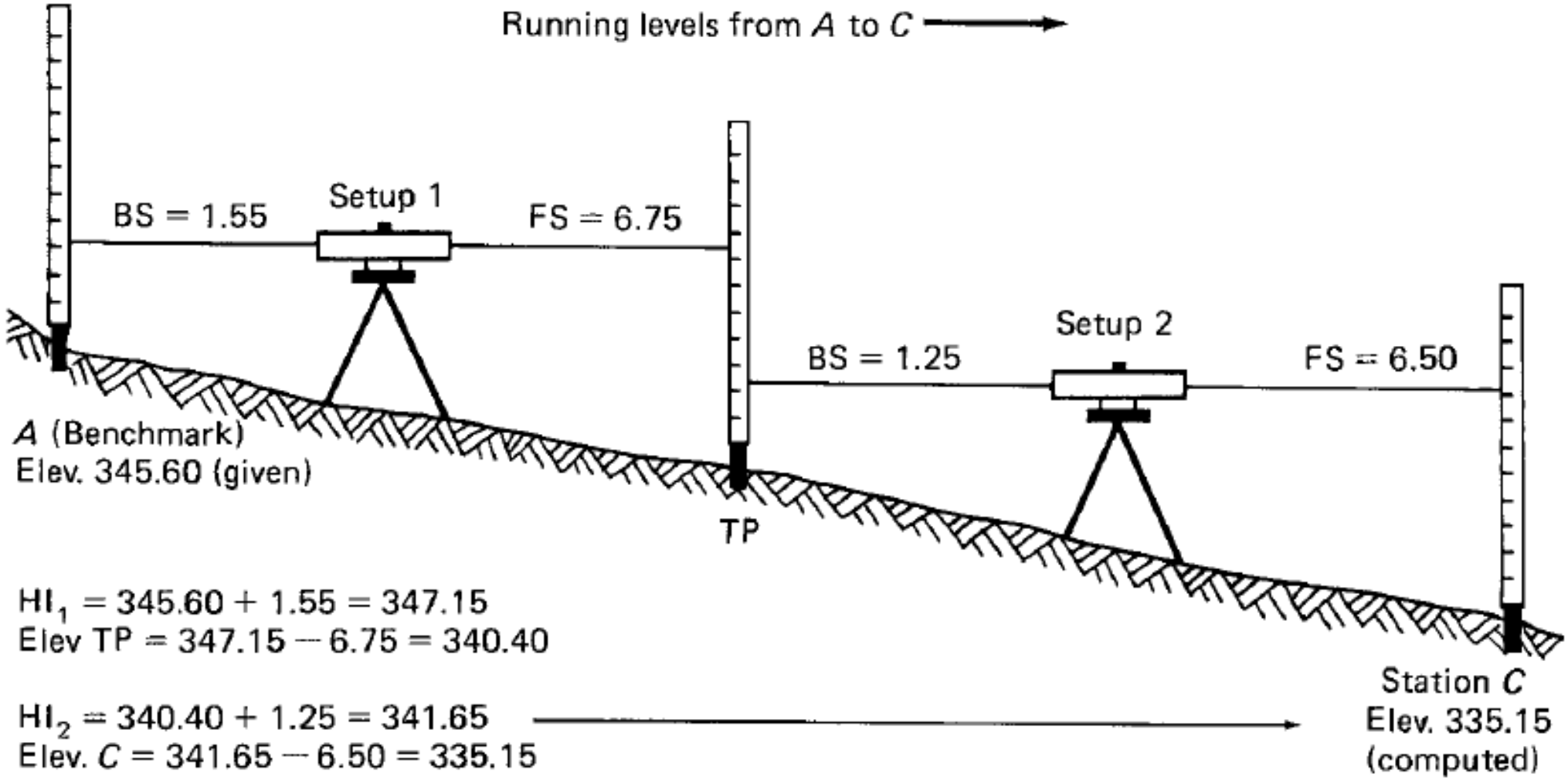
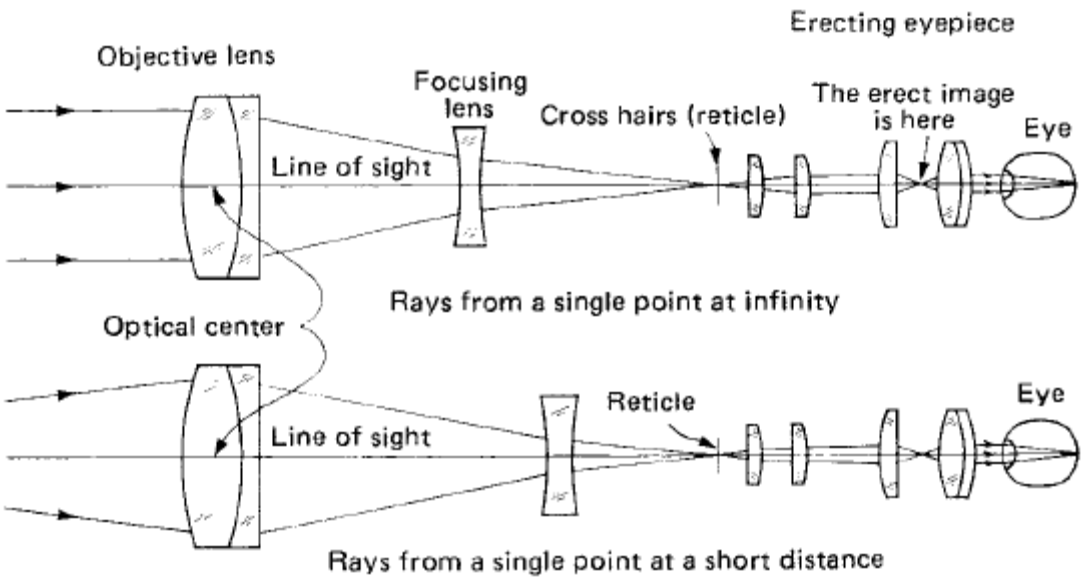
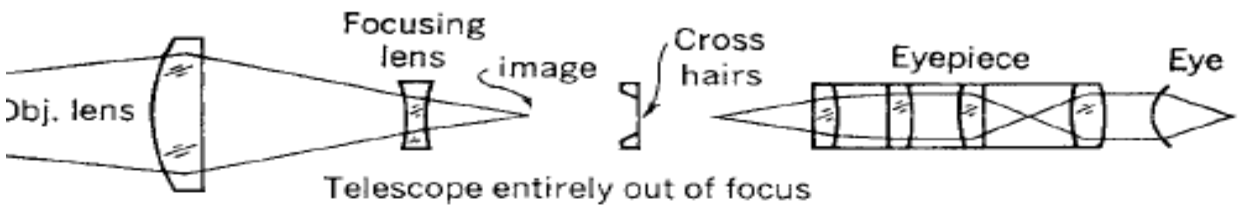
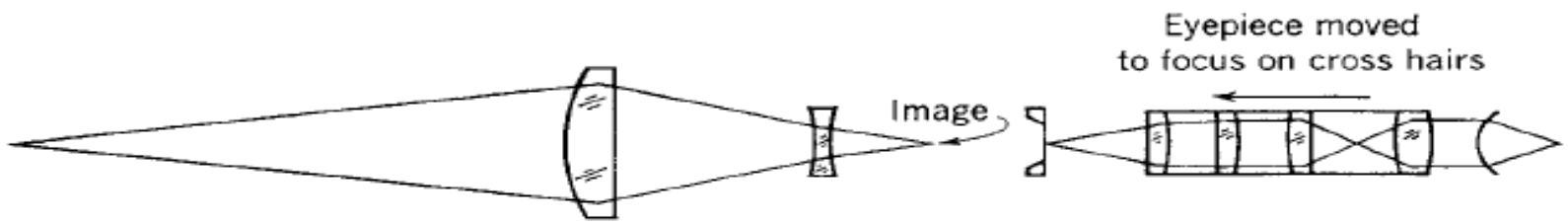


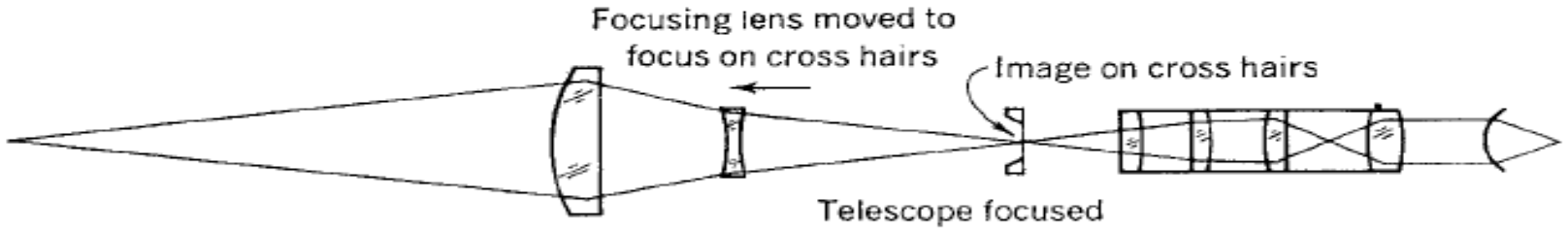
FIGURE 5-2. Temporary turning points are used to carry a line of levels from a benchmark to some other station or benchmark; the process of differential leveling is repeated at each instrument setup.



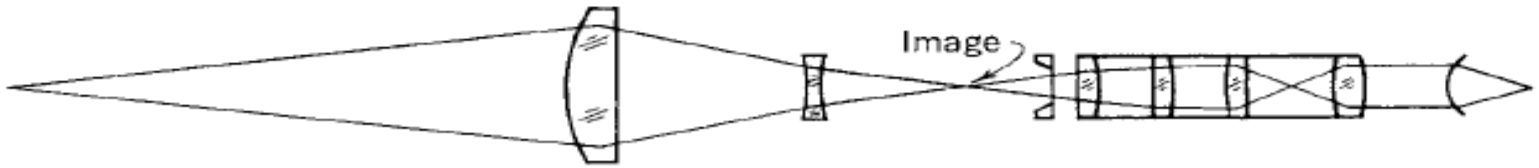


Telescope entirely out of focus





Telescope focused



Incorrect focus. While focusing lens is being moved, eye focus is changed to focus on image. This creates parallax. Eye must hold focus on cross hairs.

Accidental errors can be minimized with a properly maintained and adjusted instrument if the following steps are taken:

1. Make sure the tripod legs are secure and firmly anchored before levelling the instrument. Avoid setting up on asphalt or frozen ground because the sharp legs may slowly sink; this will change the HI. It is particularly difficult to notice such movement with a self-levelling instrument.

2. Check to see that the bubble is centered before each reading; recenter it if necessary. With an automatic level, gently tap the instrument to make sure the internal prism system is not stuck or broken.

3. Do not lean on the tripod legs when reading the rod.

4. Have the rod person use a rod level or wave the rod to make sure it is held vertically.

5. Try to keep the line of sight about 0.5 m, or 1.5 ft, above the ground when positioning the instrument, particularly when levelling over pavement on a hot day.

6. Focus the eyepiece and objective lens properly before reading the rod. It is best to get in the habit of keeping both eyes open when sighting through the telescope.

7. Without actually rushing the work (which leads to blunders), take as little time as possible between BS and FS readings.

8. Do not use very long BS and FS distances.

- Source:
    1. Practical Geography, Ashis Sarkar