FACULTY OF ENGINEERING

DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

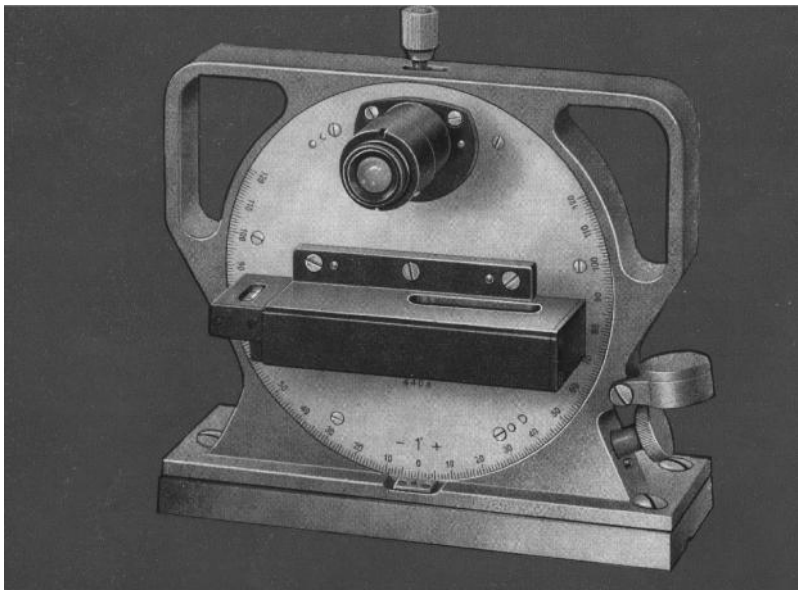
Credit Hour System

Metrology Lab 1 – MDP 240

Report On:

(14)

Levels



Metrology laboratory

Student Name	Remark
Class No:	Signature
B.N.	

Prepared by: Dr. Mohamed Ahmed Awad

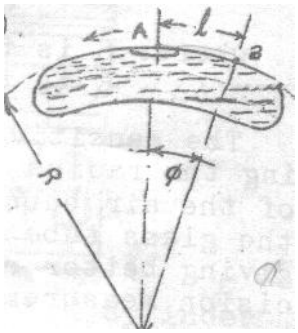
SPIRIT LEVELS

Introduction:

Levels are intended to check the leveling of horizontal and vertical surfaces during the installation and the inspection of machine tools and other types of industrial equipment, and also to measure small inclination angles.

Principle of Level

The sensitive element in levels is a curved glass tube of uniform bore, nearly filled with a liquid so that an air bubble is left.



The inside surface of the tube (vial) is ground to a radius. A scale with a scale division of 2 mm is marked on the outer surface of tube. The operation principle of the tube is that the level of liquid is always horizontal, and during tilting of the tube the air bubble is displaced to its height part. The reading is taken from the scale by the margin of the air bubble.

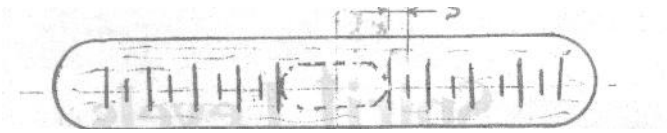
In tilting the bubble tube (vial) to an angle (ϕ) as shown in the figure, the highest point of the tube is displaced from point A to point B, thus causing a corresponding air-bubble displacement.

The relationship between tube tilt angle (ϕ), radius of curvature ® of the tube, and bubble displacement (ℓ) is defined by the formula

$$\phi = \ell / R \qquad \text{Radian}$$

The radius of curvature of the glass tube usually used in spirit levels ranges between 1 and 100 meters.

Scales of the tube designed for use in engineering should have two zero marks spaced apart from each other at a distance equal to the bubble length, and not less than eight marks to each glass tube end.



In order that the movement of the air bubble be proportional to the angle of tilt, it is necessary that the radius of the curvature of the glass tube is made constant over its whole length. The internal cross-section of the tube should be uniform. The sensitivity of the level is defined by the angle of tilt that causes a movement of the air bubble through one division of the scale engraved on the glass tube.

In the Metric system, the sensitivity is usually given in mm/m while it is expressed in the British system in radians or seconds of arc.

The scale value C of the level, which is called the level constant can be expressed by:

$$C = S/R$$

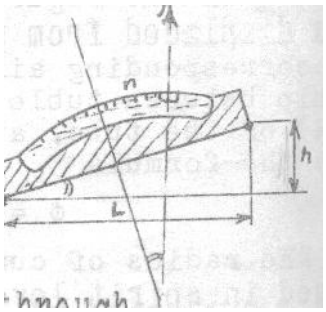
Where: S is the scale division;

R is the radius of glass tube curvature.

The sensitivity of the level increases with increasing the radius of curvature (R). Increasing the length of the air bubble and the internal cross-section of the glass tube allow the air bubble to move more quicker giving better response which is very important for precision measurement.

The difference in height (h) of the points of support of the level from the horizontal datum plane can be directly calculated from

$$h = L \cdot n \cdot C$$



Where:

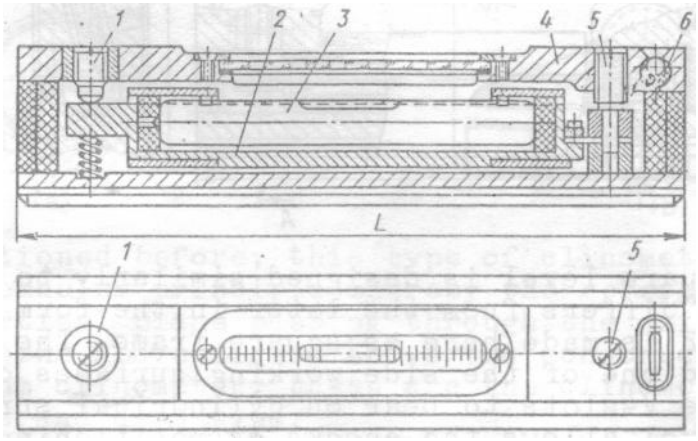
- I is the distance between the points of support;
- n is the number of divisions through which the air bubble has been deflected from the initial reading;
- C is the level constant in radians.

I - Sensitive Spirit Levels:

The sensitive level consists of a curved glass tube of uniform bore, nearly fitted with a liquid so that an air bubble is left. The tube is made of Pyrex glass. Anaesthetic ethyl either or a mixture of it with rectified ethyl alcohol is used as a filler of the tube of high and normal accuracy.

The glass tube is fitted to a metal block is such a manner that when the lower surface of the level block is horizontal, the air bubble will centre itself at the highest point of the tube, i.e. in its centre.

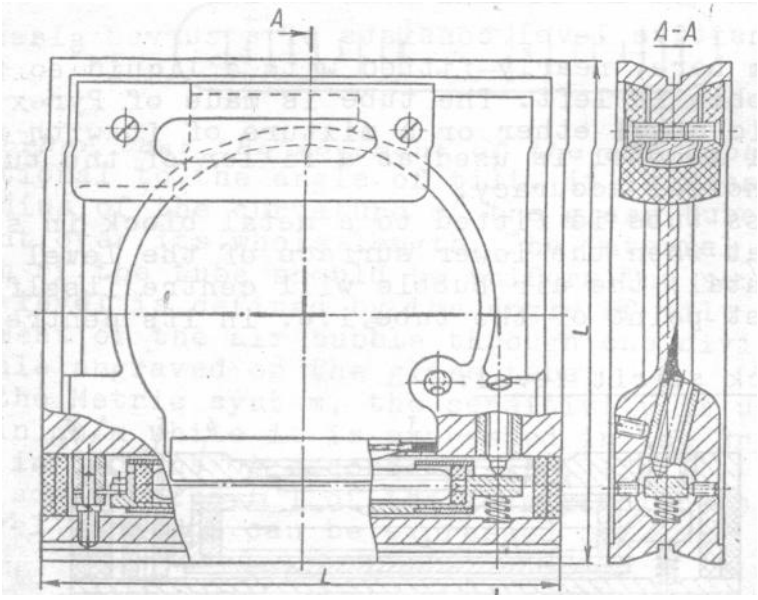
(a) Block spirit level:



The block level serves to check flat and cylinder surfaces for horizontal alignment. Base 4 of the level is provided with a V-slot on the lower bearing surface to position the instrument on cylindrical surfaces. Tube 3 is enclosed in cover 2 which is mounted inside the base by means of screw 5 through a flat spring. The other end of the cover is pressed by means of a

suitable spring to adjusting screw 1 which serves to adjust the tube parallel to the base during the level assembly a framed window, covered with a glass, is made in the base above the glass tube. Cross bubble tube 6 is located in a transverse hole of the base and is secured by pouring a hardening composition. This tube is designed to check the position of the level on cylindrical surfaces. The sensitivity per division for the cross tube is equal to 3' – 6' of arc. The length of the block base can be 100, 150, 200, 250, 300, or 400 mm.

(b) Square sprit level:



The square level is designed similarly to the block level but differs from the later in the form of the body which is made here as square frame. The lower, upper, and one of the side working surfaces of the frame have V-slots to bear on cylindrical surfaces. The square level allows the checks of positioning vertical as well as horizontal surfaces. The length of the side of the square can be 150, 200, 250, or 300 mm.

Four different classes of spirit level are available, and each class has a different range of sensitivity shown in the table:

Class	Scale value (mm/m)	Radius of curvature (m)
I	0.02 to 0.2	103.0 to 10.0
II	0.2 to 0.4	10.0 to 5.0
III	0.4 to 0.8	5.0 to 2.5
IV	0.8 to 1.6	2.5 to 1.24

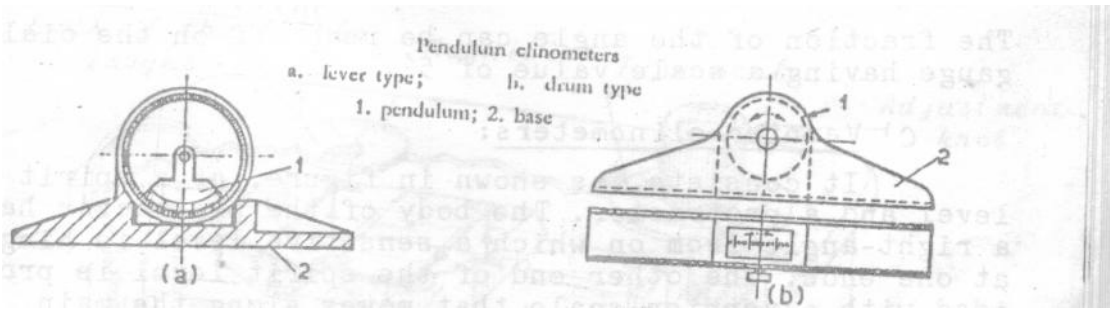
The scale division (S) for different classes is equal to 2 mm.

II - Clinometers:

A clinometer is an angle measuring instrument which employs either the spirit level or pendulum principle. A spirit level clinometer is provided with a sensitive level mounted on a rotatable turret whose angle of rotation relative to the horizontal reference plane can be measured directly or indirectly from its trigonometrical functions. Clinometers employing the pendulum principle have the vertical place as a reference.

(a) Pendulum clinometers:

As mentioned before, this type of clinometers employs the pendulum principle whereby the reference plane is the vertical plane passing through the axis of the pendulum. The above figure shows two construction types of pendulum clinometer. These are the clinometers of lever type and drum type.

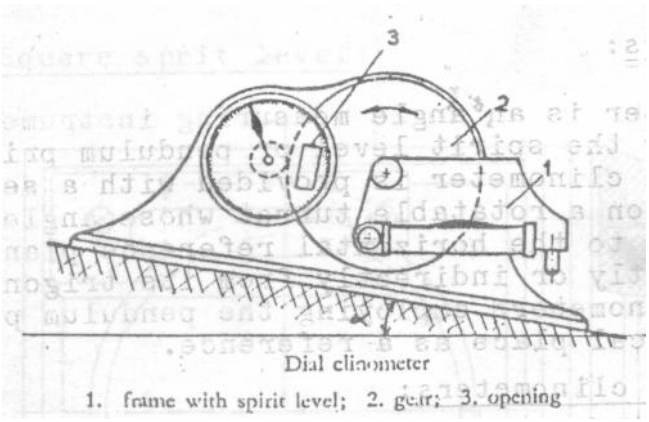


The pendulum 1 always tend to indicate the vertical direction and the main scale reading, together with the vernier scale engraved on the pendulum, indicates the required angle. The drum type clinometer is provided with a pendulum in the form of a drum 1, whose centre of gravity is outside its geometrical centre and its circumference is accurately divided in degrees. The clinometer is provided with a fixed vernier which enables accurate measurement

within 1’ to be carried out. The measuring range of the pendulum clinometers is from 0^o to $\pm 180^o$.

(b) Dial clinometers:

This type is similar in principle to the dial level protractor. The frame carrying the sensitive level is attached to a gear 2 that serves, in the same time as a circular scale for indicating the whole angle through an opening 3 in the dial.



Dial clinometer

1. frame with spirit level; 2. gear; 3. opening

The fraction of the angle can be read off on the dial gauge having a scale value of 5’.

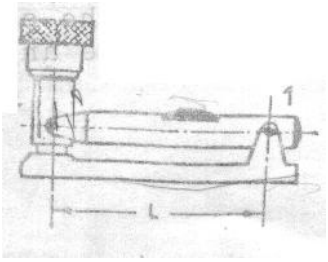
(c) Vernier clinometers:

It consists, as shown in figure, of a spirit level and a protractor. The body of the protractor has a right-angle from on which a sensitive level is hinged at one ends. The other end of the spirit level is provided with a vernier scale that moves along the main scale on the protractor body.

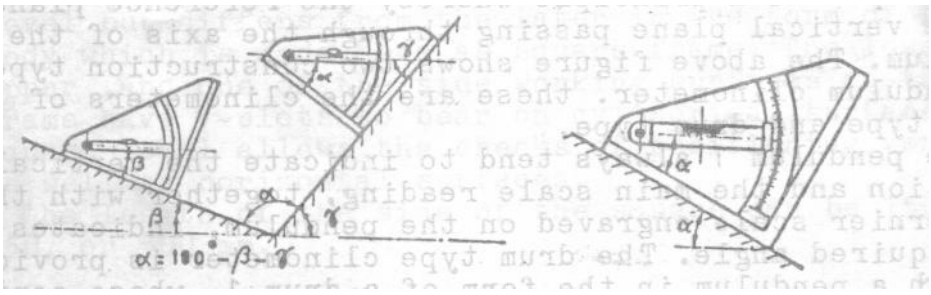
The clinometer is placed on the surface whose angle of inclination relative to the horizontal is required and the spirit level is brought to its horizontal position. The vernier on the spirit level indicates the required angle. By means of the vernier an accuracy of ± 20' can be achieved. The measuring range is 50^o from the horizontal.

(d) Micrometer clinometers: (Coincidence Level)

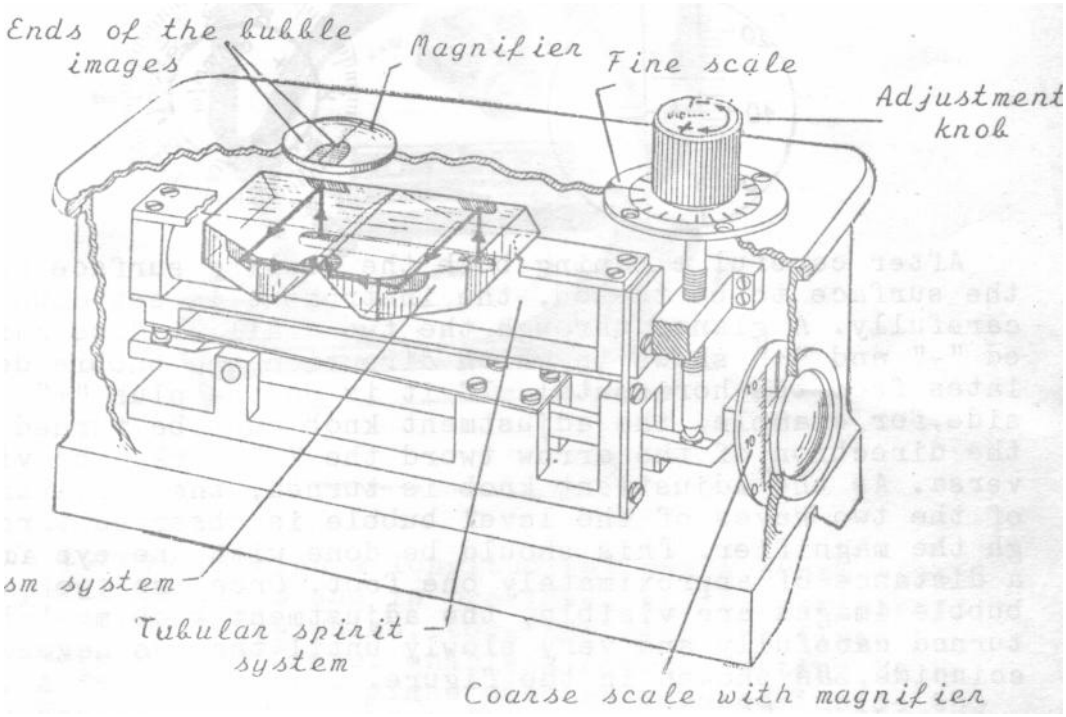
The working theory of this type is as follows:



the sensitive spirit level hinged on the instrument base as shown in figure, while the other end of the spirit is attached to the barrel of a micrometer. The spindle of the micrometer is fixed to the base at a given distance L (usually equal 200 mm) from the other hinge.



The clinometer is used to measure small angles of inclination with reference to the horizontal plane by placing the base on the surface and raising the spirit level by the micrometer until the level is accurately horizontal. The reading of the micrometer divided by distance L gives the tangent of the required angle.



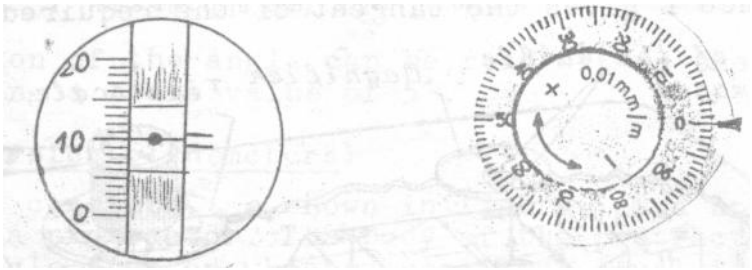
The above figure shows the mechanism of the Adjustable (micrometer) level with optically coincident images. Optical and mechanical parts are enclosed in a rugged housing. The level is set by means of the knurled knob, which is outside the frame. The fine scale disk, which is provided into 100 parts, is connected to this knob.

There is a magnifying glass at the middle of the top window through which the bubble is observed while bringing the two images into coincidence. The two smaller windows (marked – and +) to the left and right of the magnifier are used for coarse adjustment of the bubble.

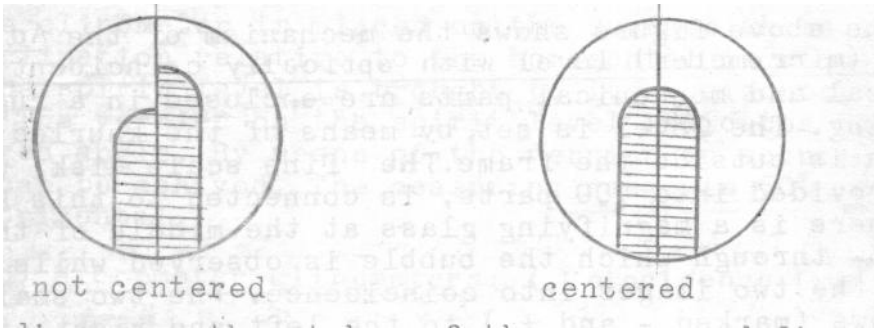
Light to illuminate the bubble enters through windows in the front and rear of the housing. The coarse scale is read through the magnifier in the front end wall of the housing. The sealing surface is precision-ground and has a V-notch (slot), so that the level can be seated on cylindrical surfaces as well.

Use of the Instrument

Before the instrument is placed on the surface to be tested, the adjustment knob must be set so that the coarse scale reads 10, and the fine adjustment scale reads 0, as shown in the figure.



After careful cleaning both the seating surface and the surface to be tested, the instrument is set down carefully. A glance through the two small windows marked ’-’ and ’+’ shows in which direction the bubble deviates from the horizontal. If it is on the plus ’+’ side, for example, the adjustment knob must be turned in the direction of the arrow toward the ’-’ mark, and vice versa. As the adjustment knob is turned, the appearance of the two haves of the level bubble is observed through the magnifier. This should be done with one eye from a distance of approximately one foot. Once the two bubble images are visible, the adjustment knob must be turned carefully and very slowly until the two haves coincide, as shown in the figure.

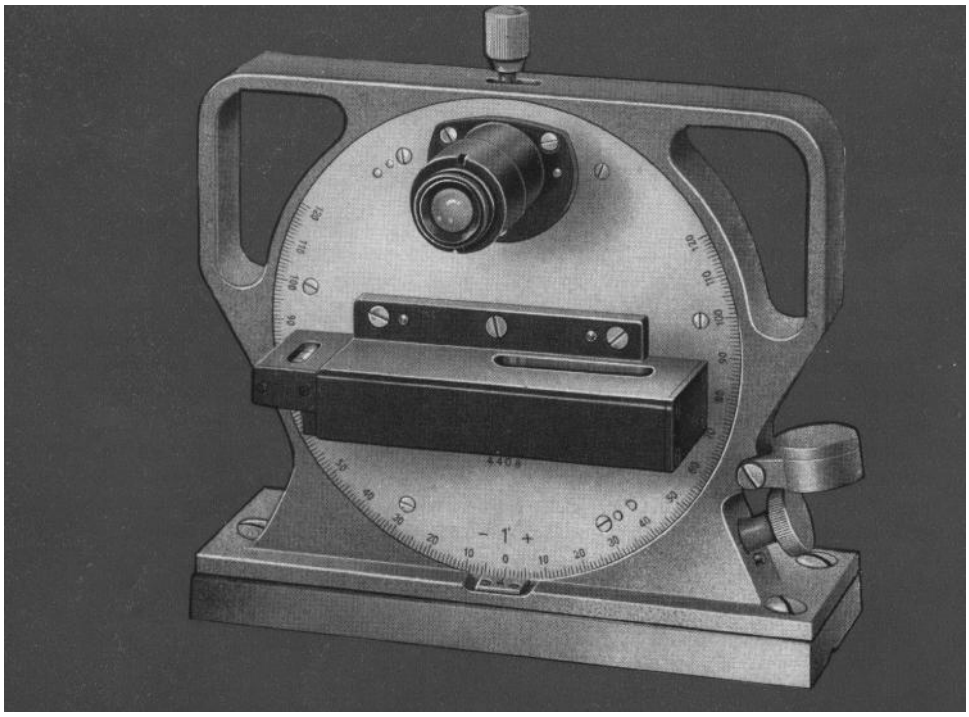


Readings are then taken of the coarse and fine scales. One division on the 100-division fine scale corresponds to a slope of 0.01 mm/m. One division on the coarse scale thus corresponds to 1 mm per meter.

(e) Optical Clinometers:

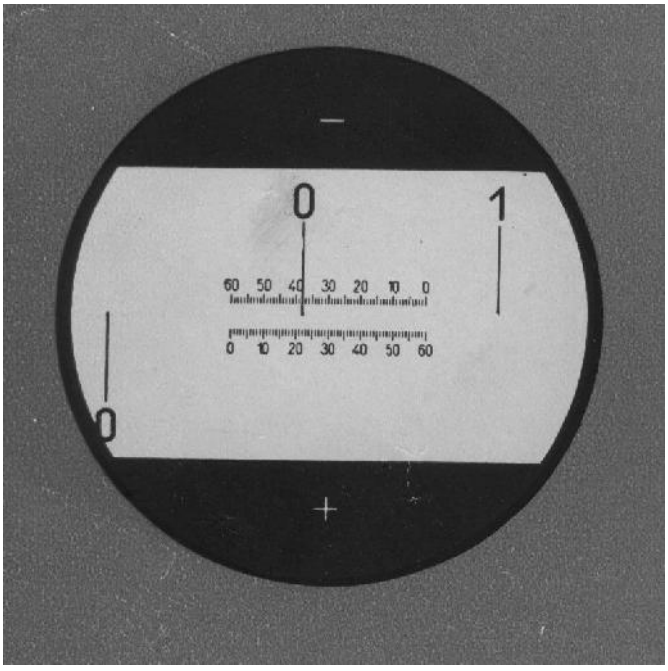
(Optical Protractor Level with Microscope).

The optical clinometer consists of a rotatable current 1 mounted on a base 2 which provided with a prismatic groove so that the instrument can be placed on flat and cylindrical surfaces.



The turret carries a longitudinal and a cross-sensitive spirit levels 3 and is provided, at its periphery, the a degree scale which, together with the fixed ale mark on the frame, enable a course setting to be. A fixed circular glass disc is mounted inside the same concentric with the turret on which a graduated ale is provided with scale division from 0^o to 120^o in directions. The turret is also provided with a measuring microscope 4 in which two vernier scales are fixed the focal-plane for the purpose of reading off the in scale. Each vernier scale is divided into 60 divisions corresponding to one degree on the main scale. The blue of the instrument is therefore, equal to 1'.

The turret can be locked with a clamping screw 5 and fine adjustment can be done with setting screw 6. the assuring microscope is illuminated through a small winding at the back-side of the frame so that the main scale the vernier scales can be easily observed.

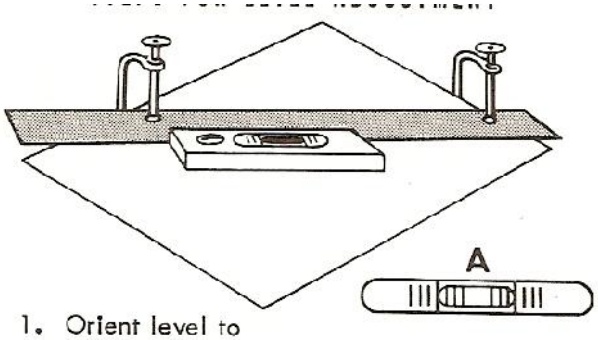


Use of the Instrument

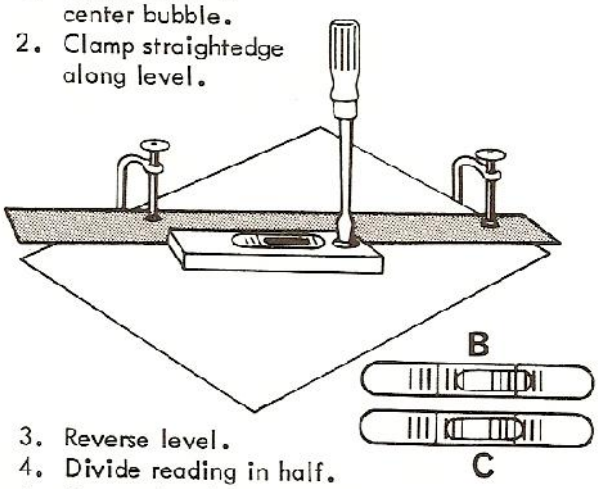
Set the instrument carefully on the test piece and turn it until the cross level 7 is centered. Loosen the knurled screw 5 and turn the turret (the rotating dial) 1 until the longitudinal level 3 begins to center.

Tighten the knurled screw, and turn the adjustable screw 6 until the bubble of the longitudinal level is centered. Read the angular value in the microscope 4.

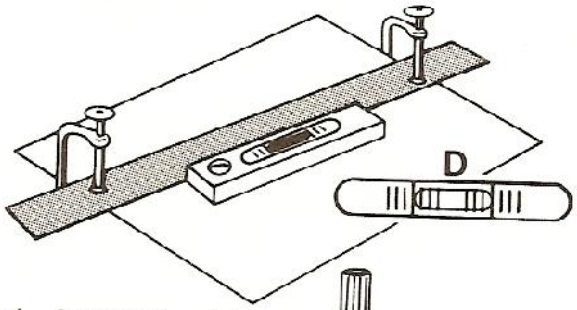
Instrument Adjustment



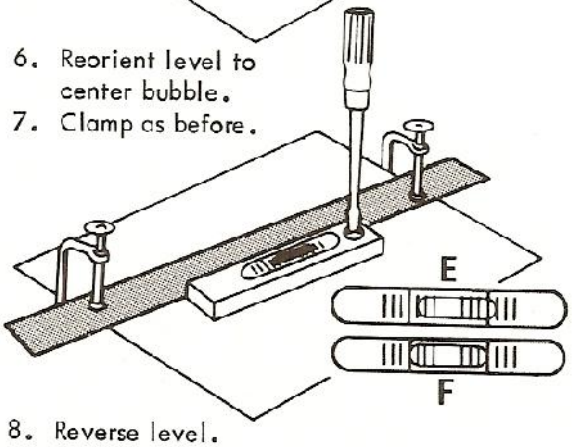
1. Orient level to center bubble.
2. Clamp straightedge along level.



3. Reverse level.
4. Divide reading in half.
5. Correct level by amount in step 4.



6. Reorient level to center bubble.
7. Clamp as before.



8. Reverse level.
9. Divide remaining reading.
10. Correct as before.

THE EXPERIMENT

Main Objective:

To study the construction, specifications and uses of the different types of levels.

Apparatus:

1. Different types of sensitive levels:
    i. Square Spirit Level;
    ii. Micrometer Clinometer; (Coincidence Level)
    iii. Optical Clinometer. (Optical Protractor Level)
2. Surface Plate;
3. Objects to be measured.

Precautions:

The following are some precautions should be taken into consider to improve the accuracy of measurements using sensitive levels:

1. Clean carefully both the seating (bearing) surface of the level and the surface to be tested;
2. Set the instrument carefully on the test surface and turn it until the cross level is center;
3. Center the bubble of the longitudinal level. Then read and record the first reading (I) of the level;
4. Replace the instrument (i.e. displaced by 180^{o}), on the marked place of the surface (the cross level must be

centered). Center the bubble of the longitudinal level and read and record the second reading (II);

5. The adjustment of the instrument is correct if the two readings (I and II) are identical, aside from their algebraic sign;

6. If the angular readings differ; calculate the adjustment value "J" as follows:

   J = Half the difference between reading I and II.

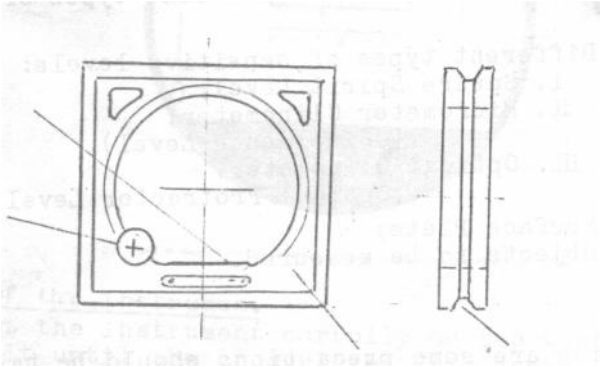
   The adjustment error "F" can be also calculated as

   F = half the sum of readings I and II.

Objective

Study the construction and the basic elements of the square spirit level. Instruct the specification and the field of usage of the given level.

1- Construction & Basic Elements



2- Specifications

Longitudinal Bubble Tube

Scale Value (level constant) =

Scale division =

Measuring range =

Tube radius of curvature =

Transverse Tube

Scale Value (level constant) =

Scale division =

Measuring range =

Dimension of seating surfaces =

Class of spirit level =

3- Field of Usage

Objective

Check the adjustment of the square level and determine the adjustment error, if existed. (See the measuring precaution page.

Readings & Results

First reading (I) =

Second reading (II) =

Adjustment value "J" = (I+II)/2 =

Adjustment Error "F" = (I-II)/2 =

Objective

Measure the inclination of the given surface plate to the horizontal. Determine the greatest inclination applying the direct and indirect method.

Readings & Results

Direct Method

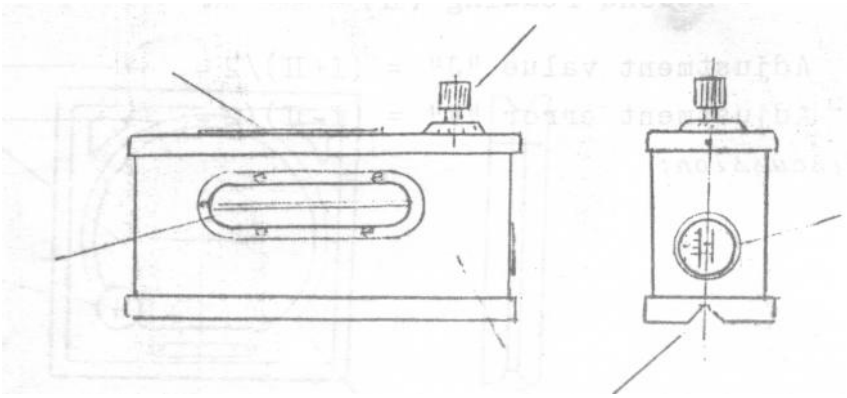
Indirect Method

Discussion

Objective

Study the construction and the basic elements of the micrometer clinometerr (coincidence level). Instruct the specification and the field of usage of the given level.

1- Construction & Basic Elements



2- Specifications

Scale Value fine scale =

Scale Value coarse scale

Scale division fine scale =

Scale division coarse scale =

Range of measurement =

Seating dimensions =

3- Field of Usage

Objective

Check the adjustment of the given Coincidence level. Determine the out of parrelism of the given object using the level

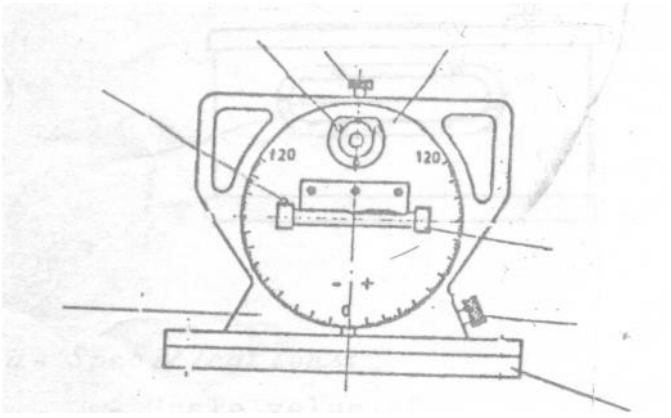
Readings & Results

Discussion

Objective

Study the construction and the basic elements of the optical protractor level with microscope (Optical clinometer). Instruct the specification and the field of usage of the given level.

1- Construction & Basic Elements



2- Specifications

Optical Protractor

Scale value
Measuring range

Longitudinal Level

Level constant
Scale division
Measuring range

Transverse Level

Level constant
Scale division
Measuring range

Dimension of base plate

3- Field of Usage

Objective

Check the adjustment of the given optical clinometers. Measure the maximum range of rotation of the given table about the horizontal axis.

Readings & Results

Discussion

General Discussion & conclusion