GEOMETRICAL FEATURE MEASUREMENT, ANGULAR MEASUREMENT AND COMPARATORS

UNIT -3

Geometrical feature measurement

SLIP Gauges ,Straightness measurement - straight edge ,wedge method ,sprit level ,Auto Collimator

Squareness testing -Engineers square ,indicator method Optical test using Auto Collimator

Flatness measurement -Comparison with the Liquid dial indicator ,Roundness measuring machine, Bench center method

Angular Measurement

Optical bevel protractor ,sine bar ,Angle gauges and Angle dekkor

Comparators

Twisted strip mechanical comparator ,Optical level comparator, Optical projector ,Electric comparator ,Pneumatic comparator

The specification of geometrical tolerance in addition to the normal dimensional tolerance is becoming a common practice because :

1.The geometrical accuracy of the component is as important as their size for its correct functioning with the mating parts.

2. It also influences the wear on the moving part

3.It is of fundamental importance for correct functioning of the measuring instruments · and machine tools, where the ability of slides to move along straight lines-and spindles · to rotate about a fixed axis is essential.

4.For stationary locating parts, the geometrical inaccuracy may affect the class of fits required as the clearance between the mating parts may be changed.

Slip Gauges or Gauge blocks

- Slip gauges are used in the manufacturing shops as length
- They are not to be used for regular and continuous measurement.
- Slip gauges are rectangular blocks with thickness representing the dimension of the block.
- The cross-section of the block is usually 32 mm x 9 mm.
- These are small blocks of alloy steel.
- The slip gauges are hardened and finished to size.
- The measuring surfaces of the gauge blocks are finished to a very high degree of finish, flatness and accuracy.

Slip Gauges or Gauge blocks

Gauges blocks are used for

- Direct precise measurement, where the accuracy of the workpiece demands it.
- For checking accuracy of vernier callipers micrometers, and such other measuring instruments.
- Setting up a comparator to a specific dimension.
- For measuring angle of workpiece and also for angular setting in conjunction with a sine bar.
- The distances of plugs, spigots, etc. on fixture are often best measured.with the slip gauges or end bars for large dimensions.
- To eheck gap between parallel locations such as in gap gauges or between two mating parts.

Wringing of Slip Gauges

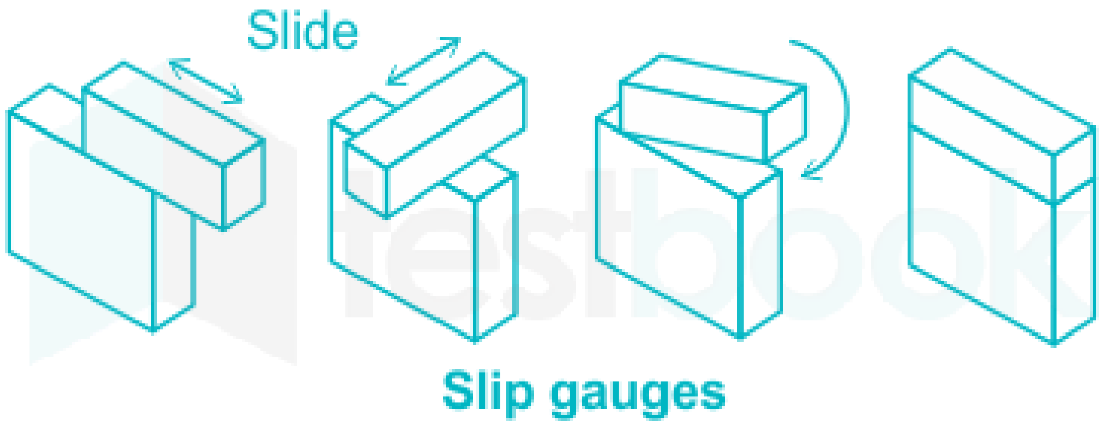
The success of precision measurement by slip gauges depends on the phenomenon of wringing. The slip gauges are wrung together by hand through a **combined sliding and twisting** motion. The gap between two wrung slips is only of the order of 0.00635 microns (0.635 x 10-·3 mm) which is negligible.

Procedure for Wringing

(i)Before using, the slip gauges are cleaned by using a lint free cloth, a chamois leather or a cleansing tissue.

(ii)One slip gauge is then oscillated slightly over the other gauge with a light pressure.

(iii)One gauge is then placed at 90° to other by using light pressure and then it is rotated untill the blocks one brought in one line.



STRAIGHTNESS

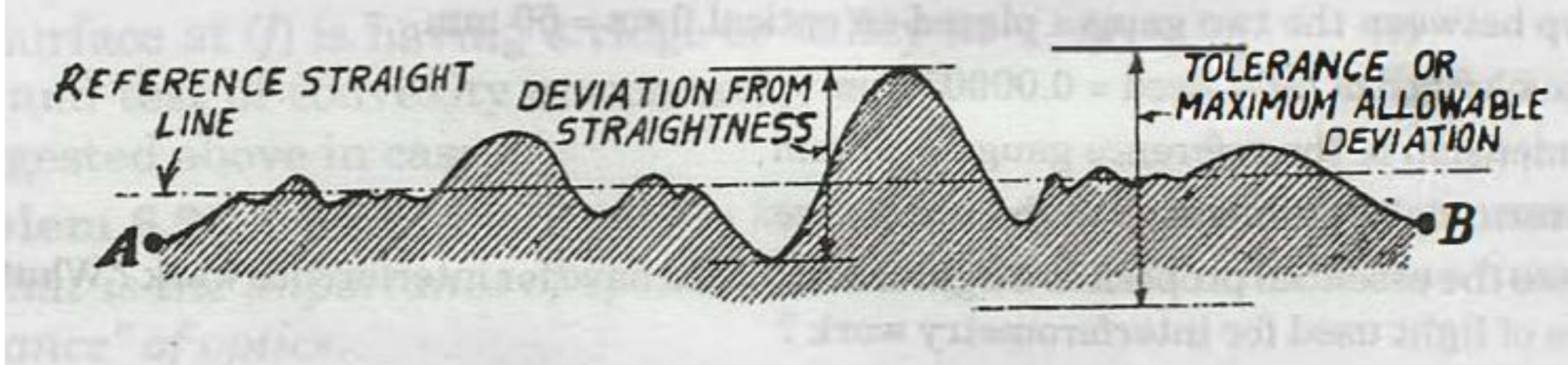


Fig. 7.1: Tolerance on straightness of a line.

- A line is said to be straight over a given length, if the variation· of the distance of its points from two planes perpendicular to each other and parallel to the generation direction of the line remains within the specified tolerance limits

- The reference plane being so chosen that their intersection is parallel to the straight line joining two points suitably located on the line to be tested and the two points being close to the ends of the lengths to be measured

STRAIGHTNESS

The tolerance on the straightness of a line is defined as the maximum deviation in relation to the reference straight line going the two extremities of the line under examination.

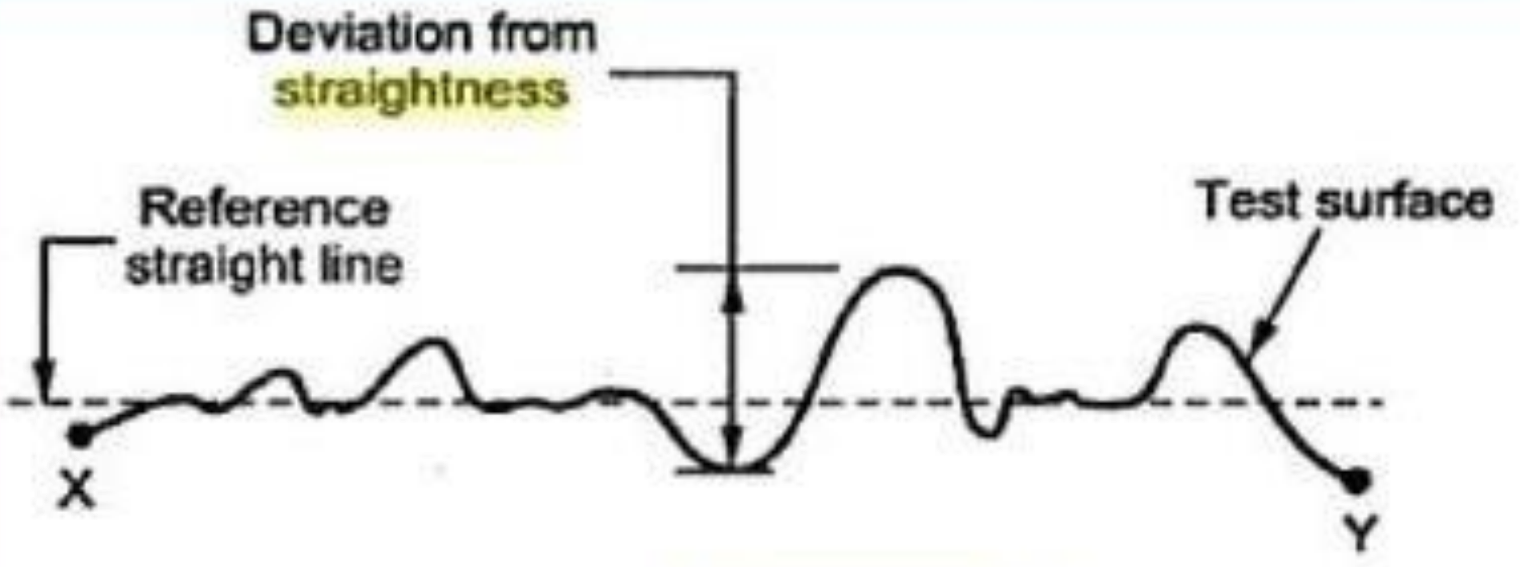


Fig. 2.2 Straightness

Wedge Method

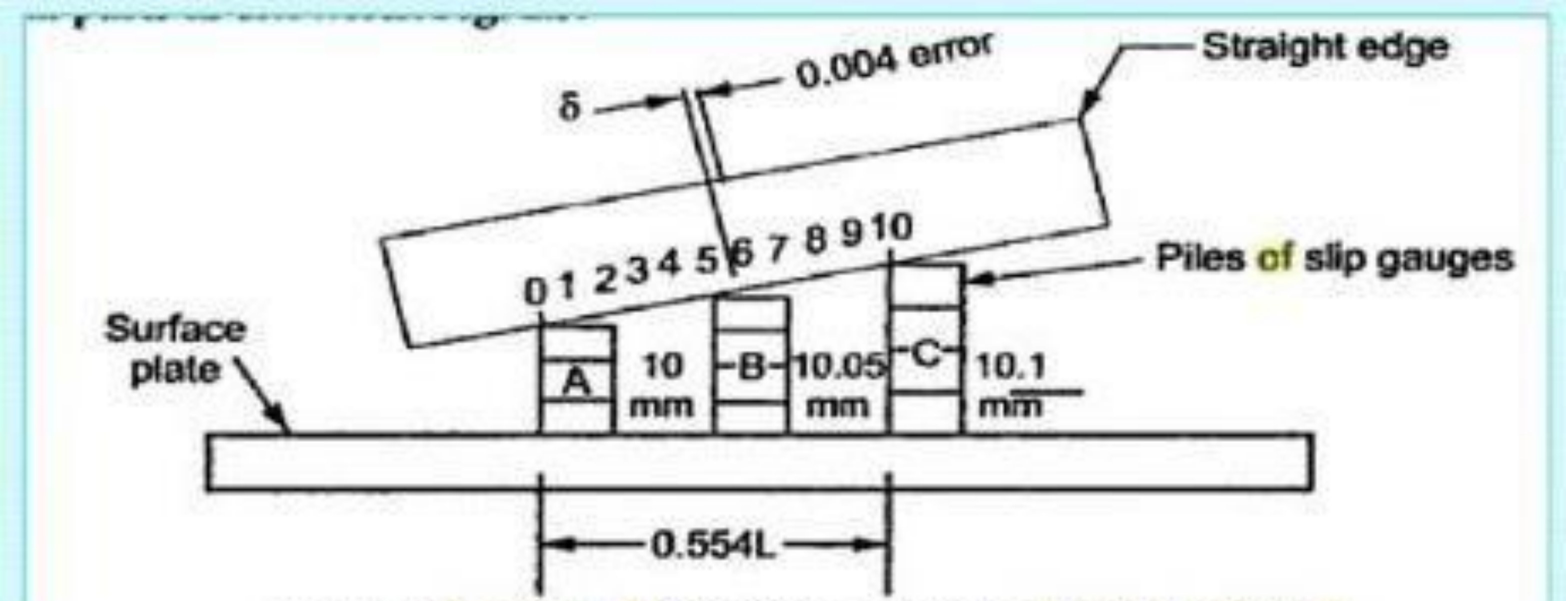


Fig. 2.3 Testing of Straight edge by wedge method

In this method the straight edge is supported at the points for minimum deflection on two unequal piles of slip gauge witch rest on a surface which is straight or which is to be check the difference between the slip values is made definite say 0.1mm the distance between the two piles is divided in to number of equal parts of shown in figure.

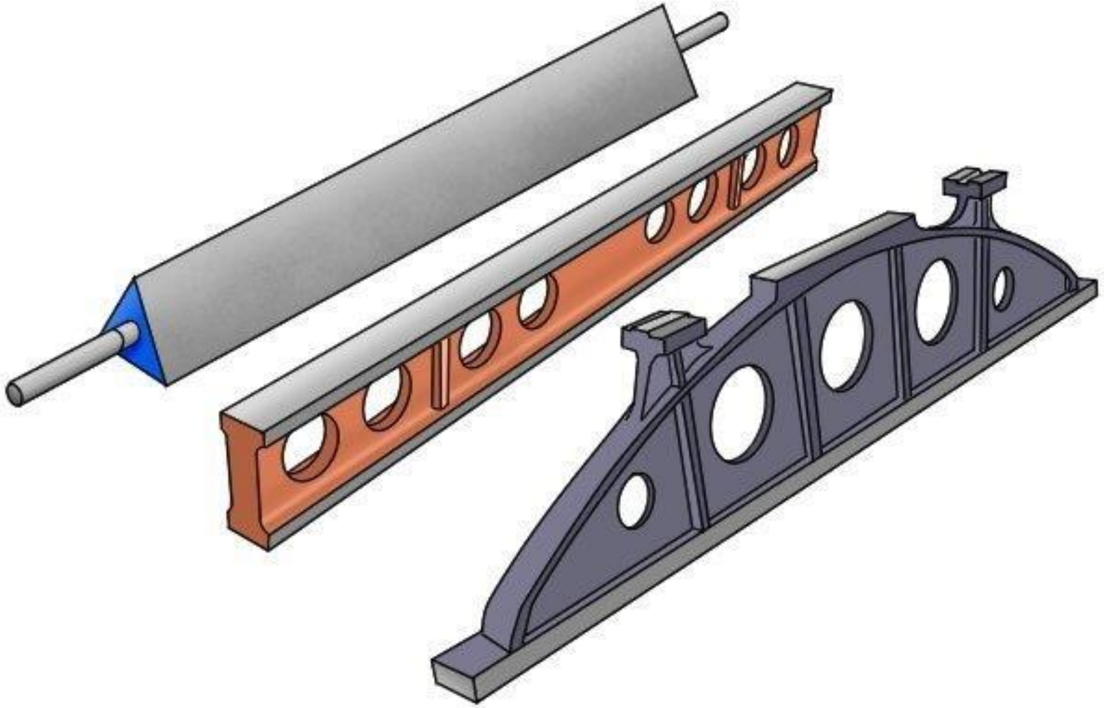
Wedge Method

- The distance 0.1mm can be divided into equal parts i.e. each division will become 0.01mm .if the straight edge is true & if the surface is straight then piles of slip gauge of different size will touch at exact points

for example say pile of 10.05 mm is made by adding slip gauge skid the pile below

- The straight edge if the given surface is exactly straight then the set of pies will exactly touch at mark no.5 whose height above the surface is 10.05mm thus the different combination will give the idea regarding the straightness of the given surface care must be taken that the slip gauge must not wring to surface otherwise all sensitivity will be lost.

Straight edge Method



In this method tool makers edge and white light source is used. The method is explained in following step:

- Keep true straight-edge on the work surface and project them against the light source and observe from other side.
- The gap between true straight-edge and work surface is the straightness error and light rays passing through this gap will get diffracted and different colours will be seen Colour of this diffracted light rays will indicate the straightness error.

Straight edge Method

- If the colour of light be **red,** it indicates a gap of **0.0012 to 0.0017** mm

  while for **blue light**, gap is approximately **0.0075**

- With this method straightness of shorter surface produce by lapping can be known with 0.005 mm accuracy.

Autocollimator method

Autocollimator method

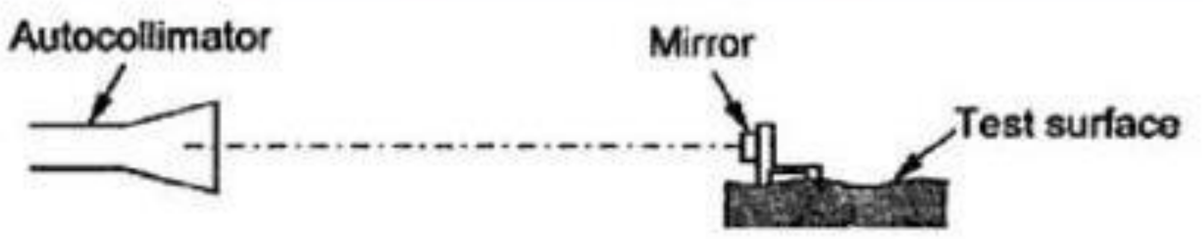


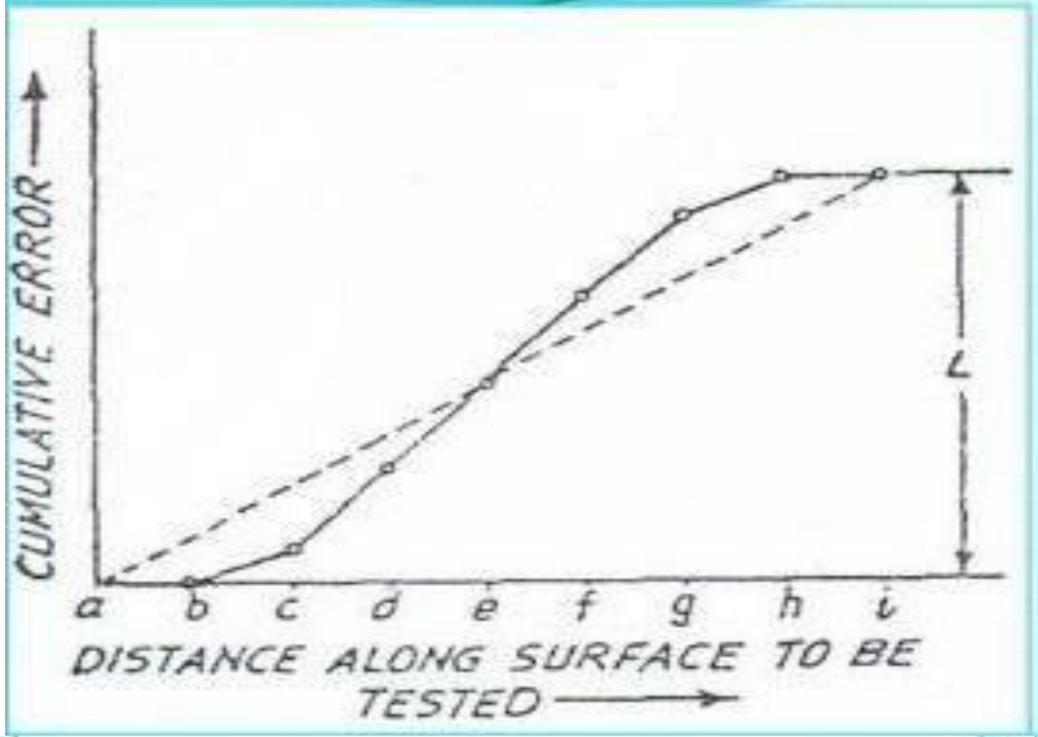
Fig. 2.5 Straightness test by Autocollimator

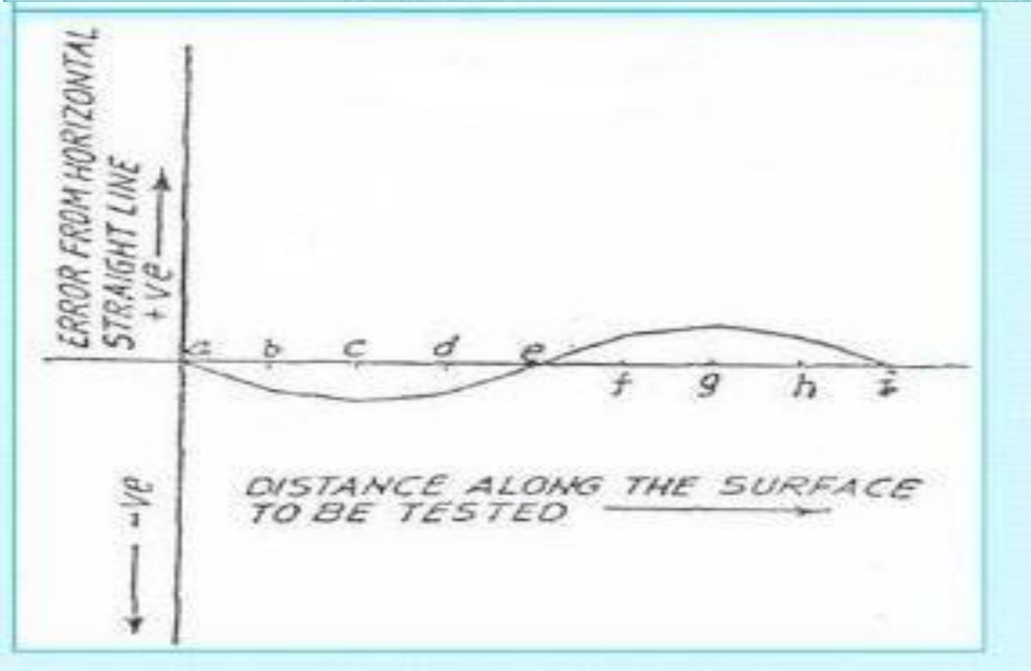
- The principle of this method is same as that of level method only the apparatus used is different
- This consist of a block with two feet carried a plane mirror having its reflecting surface approximately at right angles to the line joining feet as the block is stepped along the angular variations are measured by means of an autocollimator set to receive the reflection from the mirror the reading of the angle of tilt are converted into differences in height of the feet (nnin=o.o3mm) & the contour is plotted as in previous method

Autocollimator method

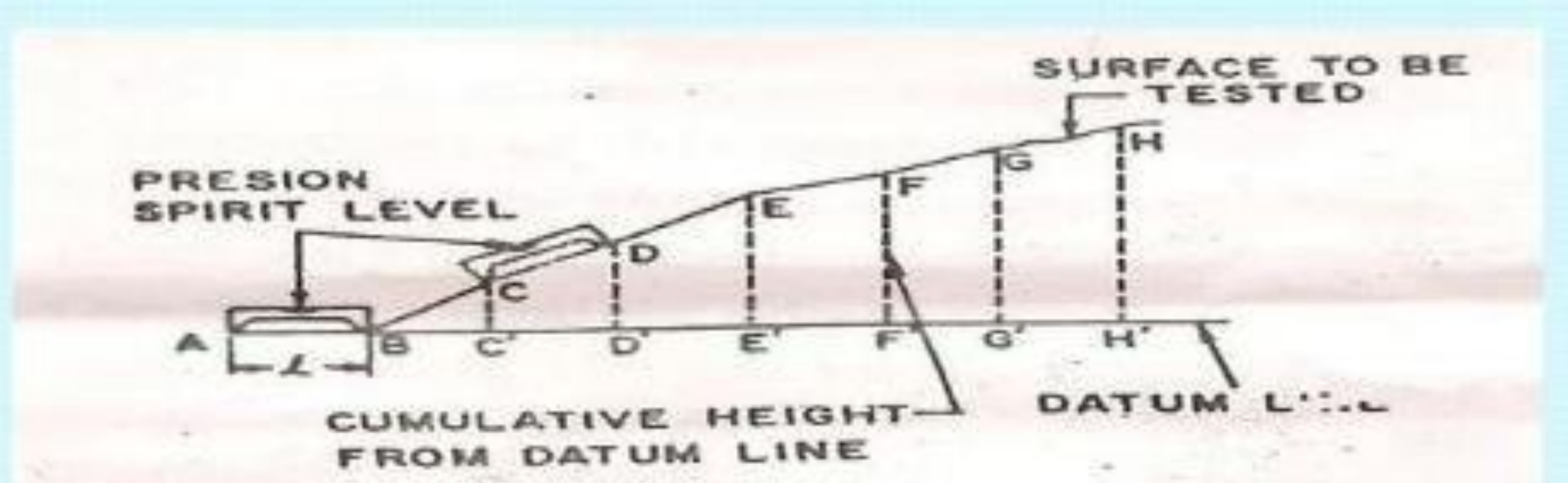
- The errors of any surface may be required relative to any mean plane. If it be assumed that mean plane is one joining the end points then whole of graph must be swung round until the end point is on the axis.

- The work surface profile at zero position like point A or 1 calculation, new graph is drawn as in figure and straightness error is found out





Sprit level



(Fig. 4.11 : Checking staightness using pricision spirit level)

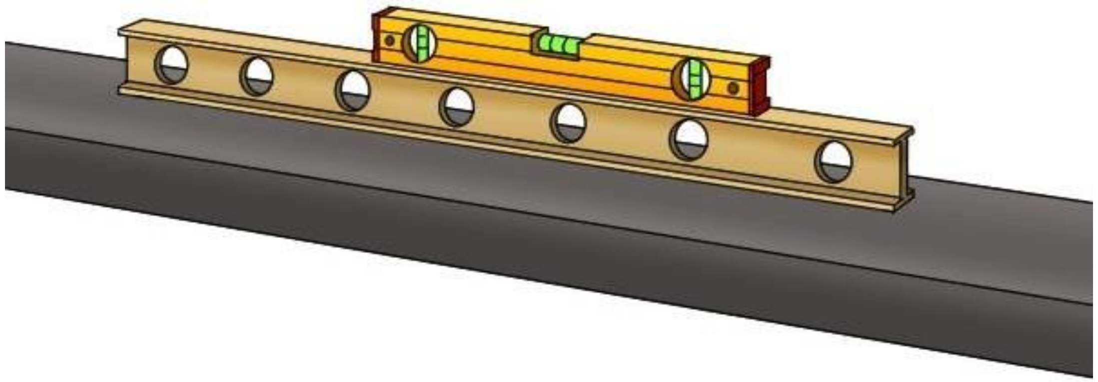
This method is similar to autocollimator method . Here precision sprit level is used .

The method is explained in following steps:

A straight line is drawn on the work surface and divided in to equal parts having distance equal to the length between two feet of spirit level support(1). These part are marked like AB ,BC ,and CD etc.

Sprit level

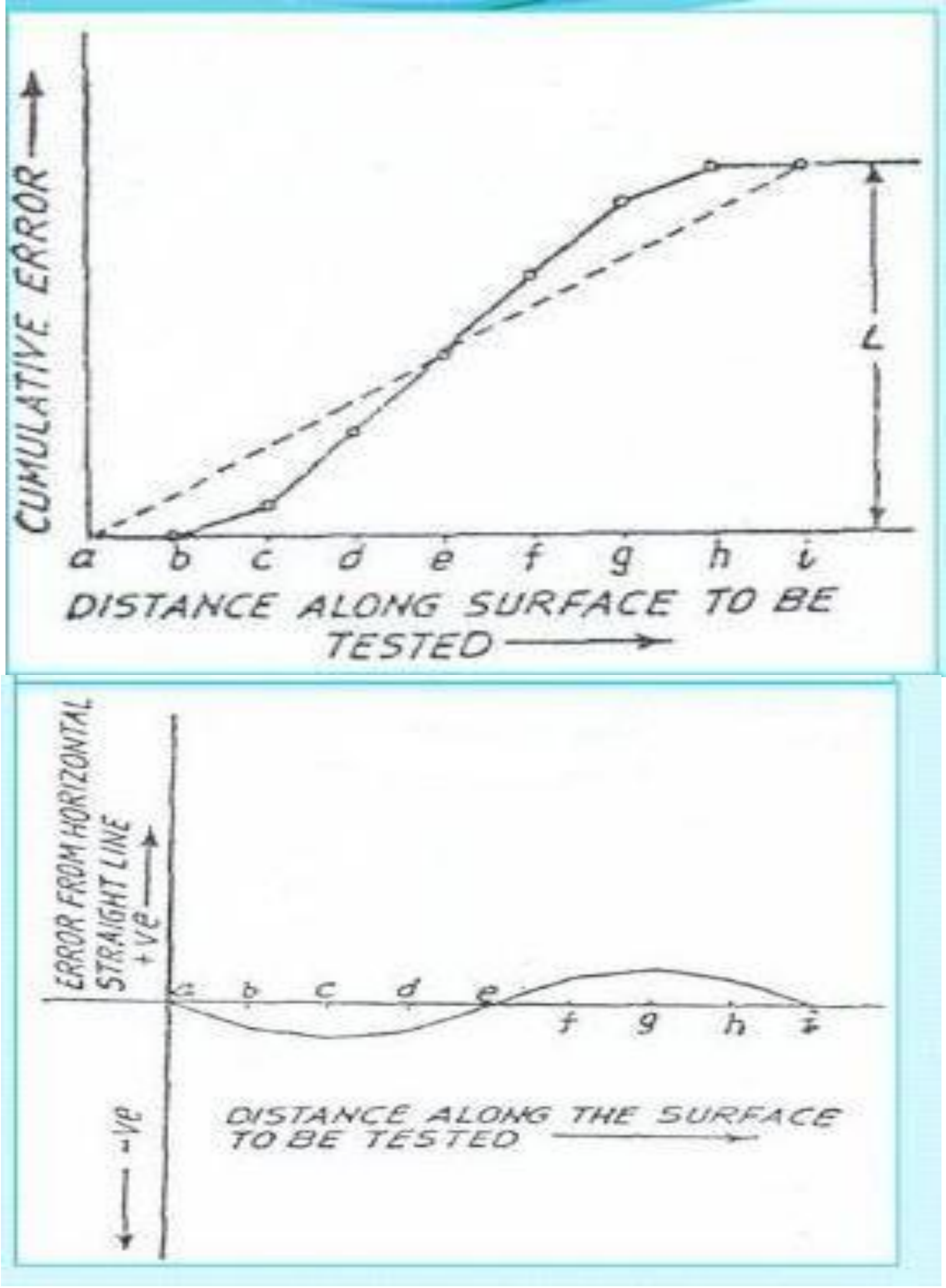
- As shown in figure spirit level is adjusted on part AB and first reading is taken. Thereafter spirit level is kept on other location on the line such as BC,CD,DE etc and reading is taken these reading indicate angular deviation of work surface in seconds. The reading are noted in the manner as shown in table 4.1 line AB is extended and considered as datum line.



Sprit level

- The reading achieved as above are then represented in the form of graph as done in autocollimator method and the error s found out.

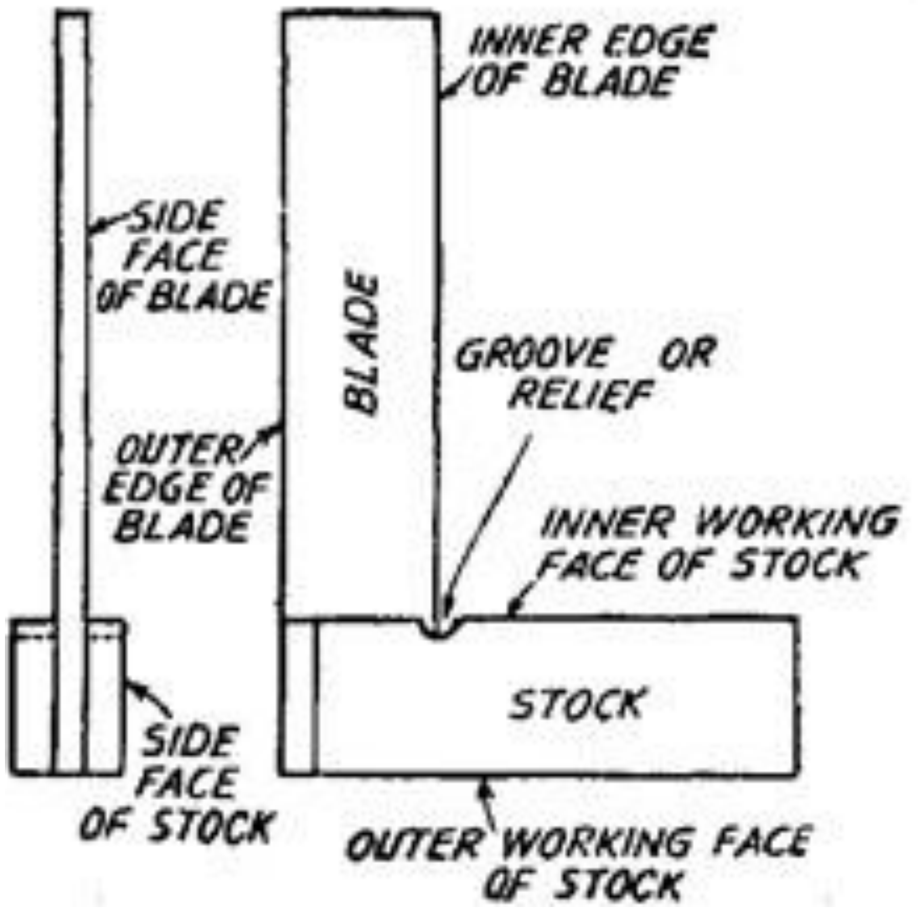
- With this method straightness of shorter or longer horizontal surface can be checked with accuracy of 10"



Squareness :

Checking whether one plane is at right angles to another plane is called squareness testing.

- Two planes, two straight lines or a straight line and a plane are said to be perpendicular when the error of parallelism in relation to a standard square does not exceed a given value.
- The reference square may be a metrological square or a right angle level or may consists of kinematic planes or lines.



Flatness

Squareness :

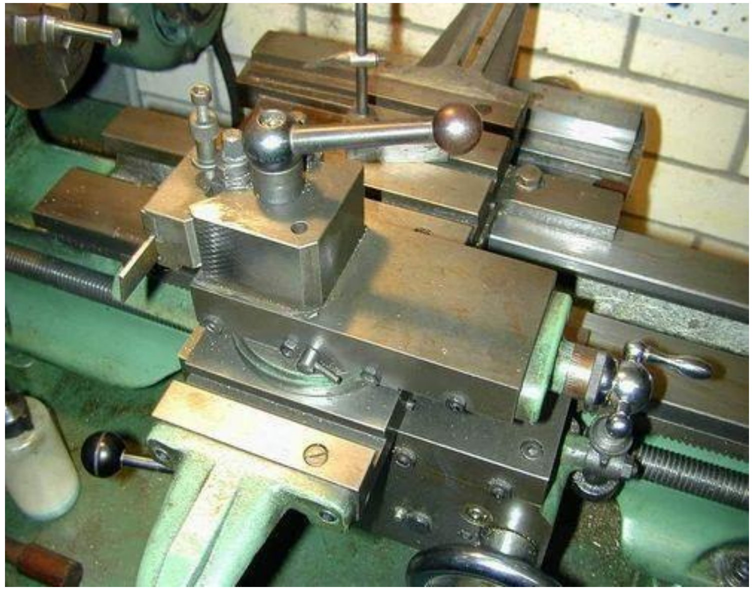
- The permissible errors are specified as 'Errors relating to the right angle : ± ... µ or mm on a given length'

- The angle of 90° is probably the most important angle in engineering applications.
- Probably the achievement of modern sciences would have not reached the present state of advancement if right angle was unattainable to within a close degree of accuracy.

Its importance is realised from the following applications.

- ❑ The cross slide of lathe must move exactly at 90° to the spindle axis in order to produce a flat face during **facing operation.**

Its importance is realised from the following applications.



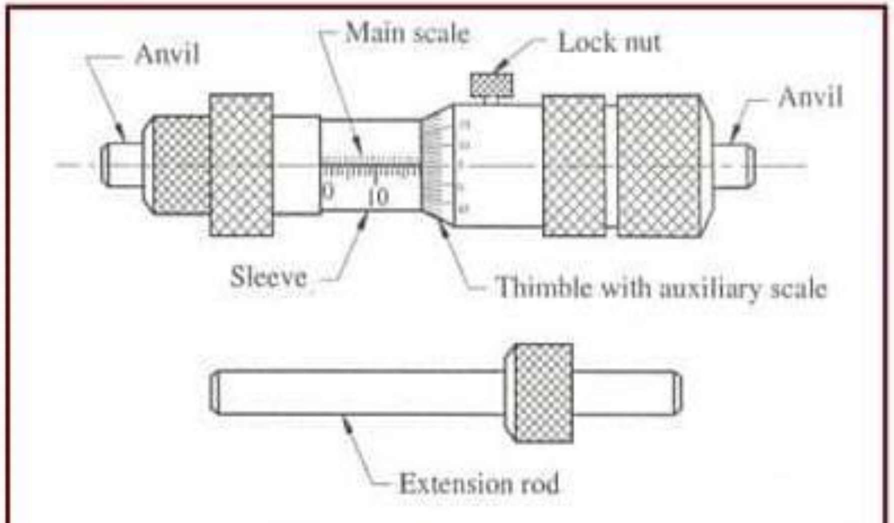
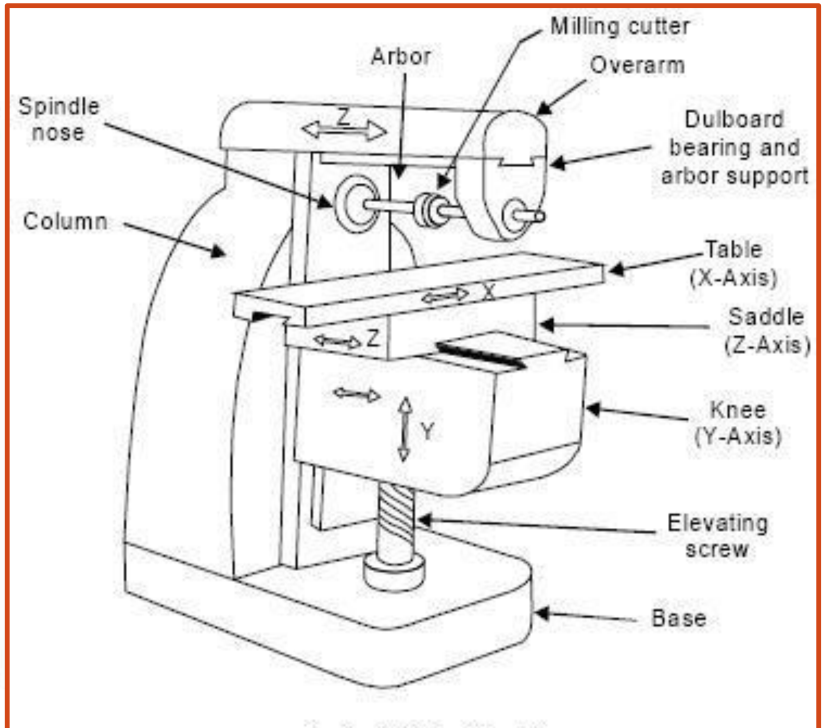


Fig.1.26 – Inside micrometer



Vertical Milling Machine

- The cross slide of lathe must move exactly at 90° to the spindle axis in order to produce a flat face during **facing operation.**

- The spindle of depth micrometer must be square to the locating face in order to avoid any errors in measurement.

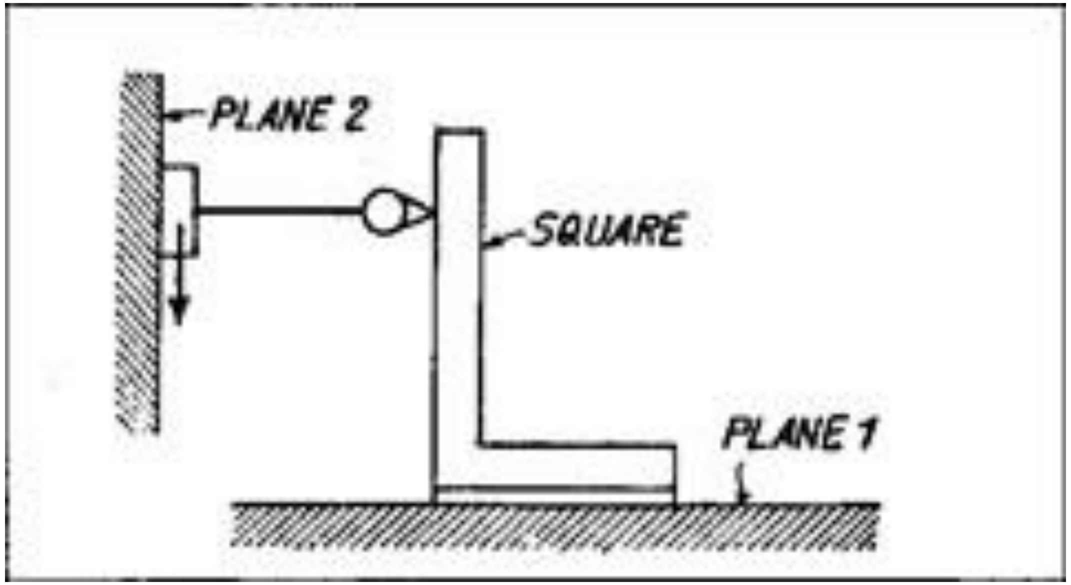
- The column and table of milling machine must be at 90° to each other.

In order to know the amount of error and for checking squares and square blocks, the following methods can be used:

Indicator Method:

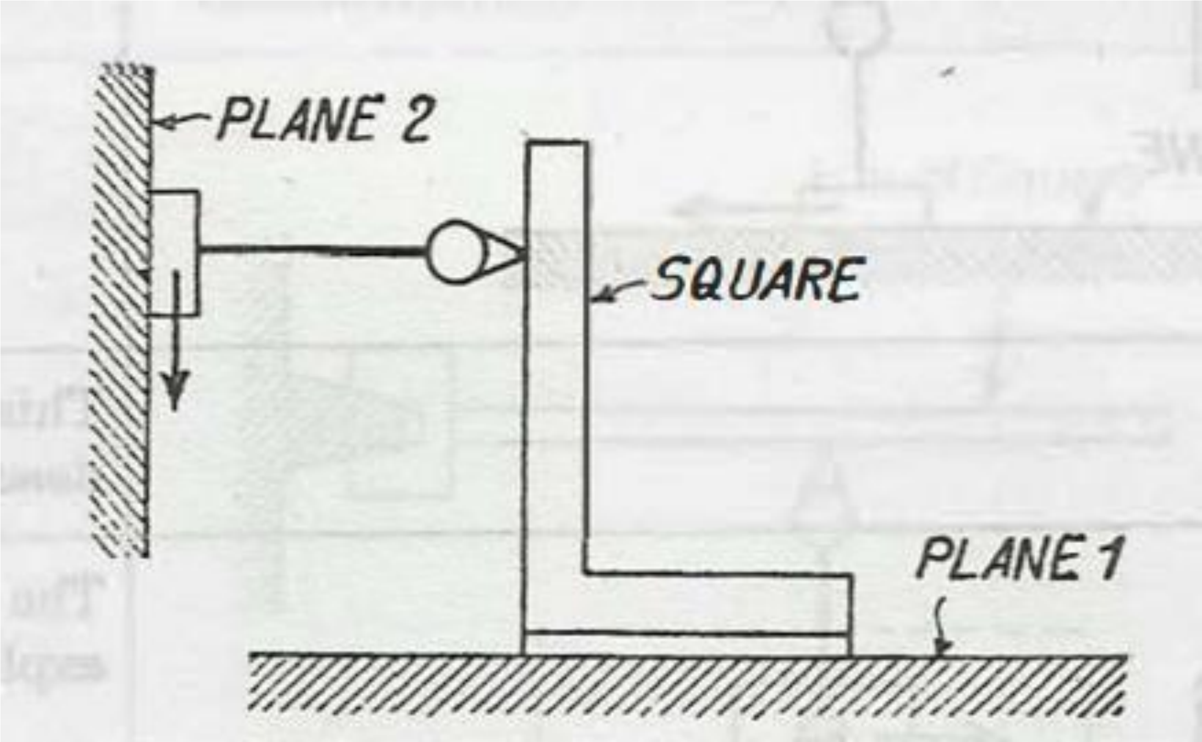
- This method is particularly suitable for checking the squareness of a block whose opposite faces are supposed to be parallel.
- It is assumed that the squareness of the block has already been assured to a reasonable accuracy by the use of square etc., as otherwise the full sensitivity of the method can't be obtained.

The instrument for this purpose is designed by N.P.L. and is very suitable for checking squareness while manufacturing a square block. The instrument consists of parallel strip (framework) and a flat base. A knife edge and some form of indicator is mounted on the framework as shown in Figure



(i) Two planes (1 and 2) at 90^0 to each other

Squareness of two planes 1 and 2 is checked by placing the square on one plane and then checking the parallelism of 2nd plane with the free arm of the square by sliding the dial indicator ,(mounted on a base) along 2nd plane and its feeler moving against free arm of the square.



(ii) Two axes at 90^0 to each other (a) Both axes fixed

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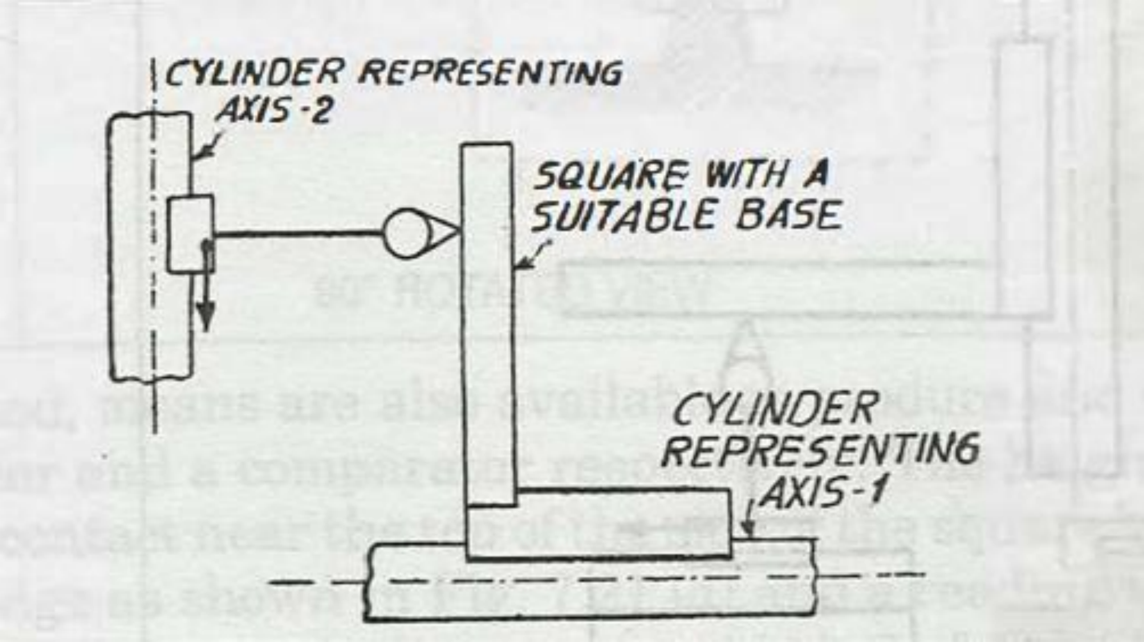
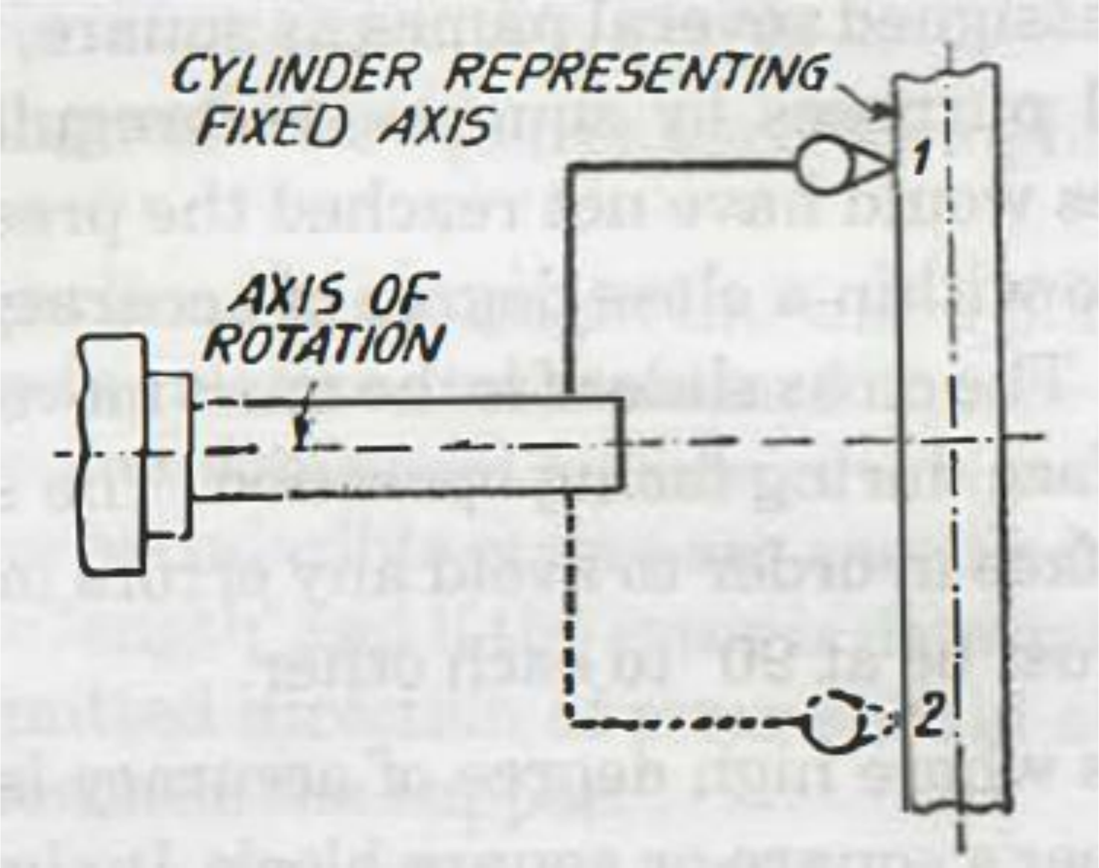
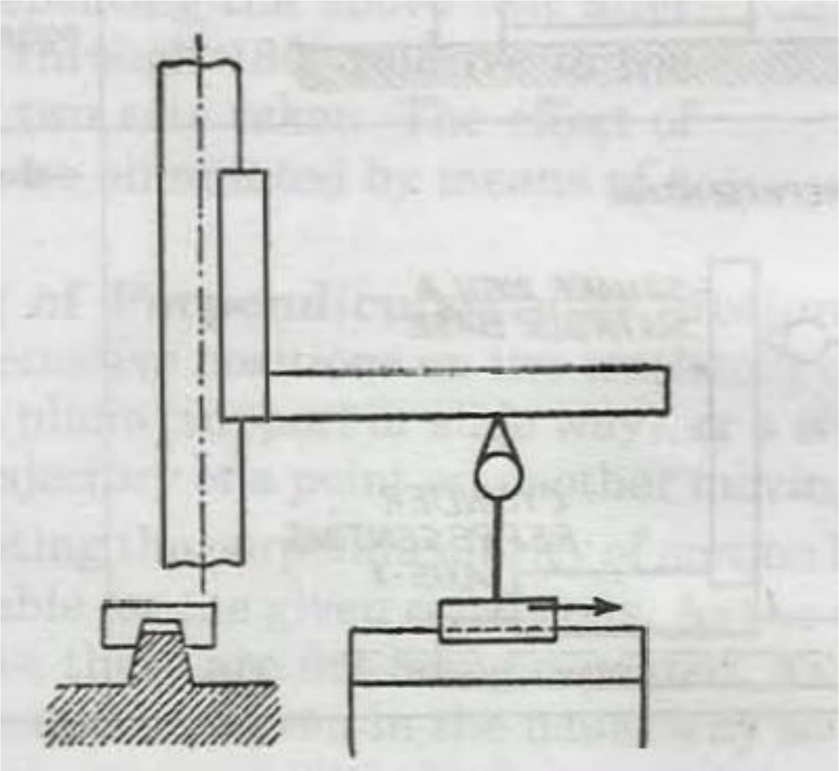


(iii) One axis being axis of rotation and ether fixed.

The dial gauge mounted on arm and fixed on the mandrel is brought into contact with the cylinder representing fixed axis at two points 1 and 2, 180° apart and deviation expressed in relation to distance between 1 and 2.

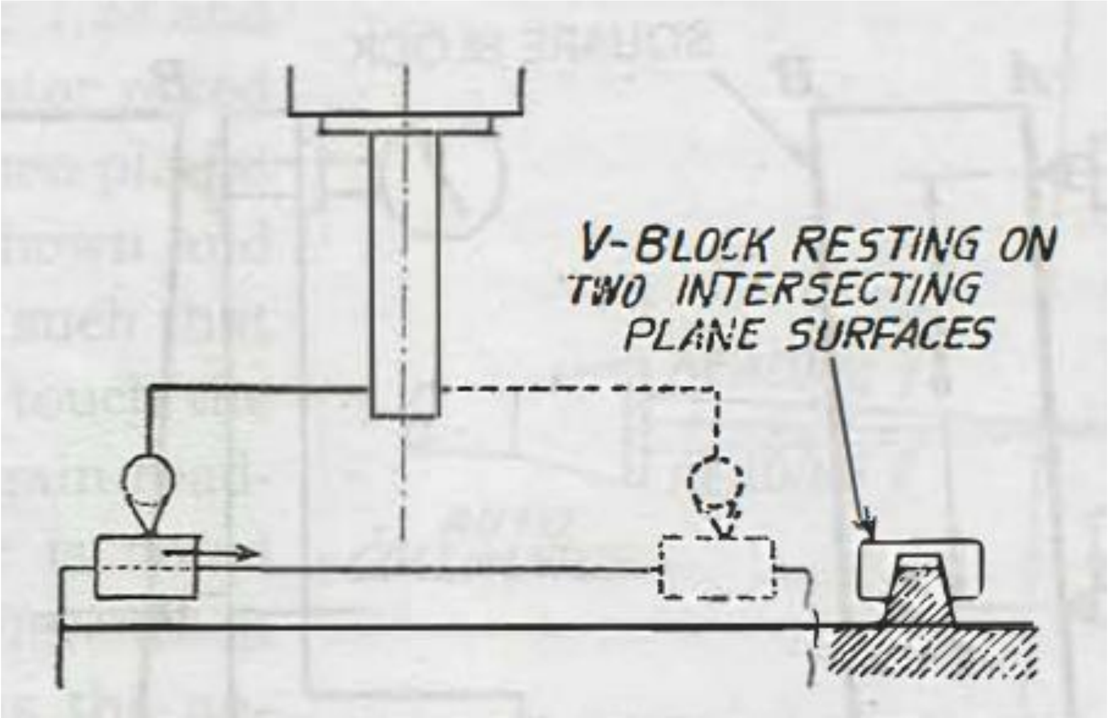


(iv) An axis at 90° to the intersection of two planes. (a) Axis is fixed

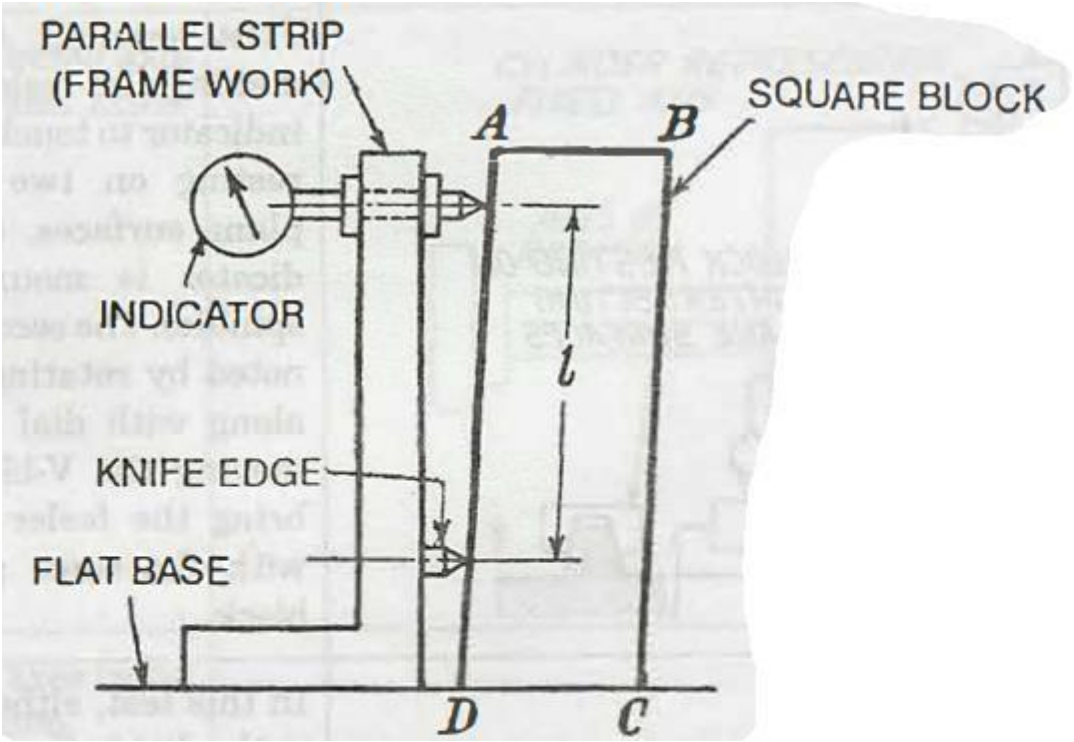


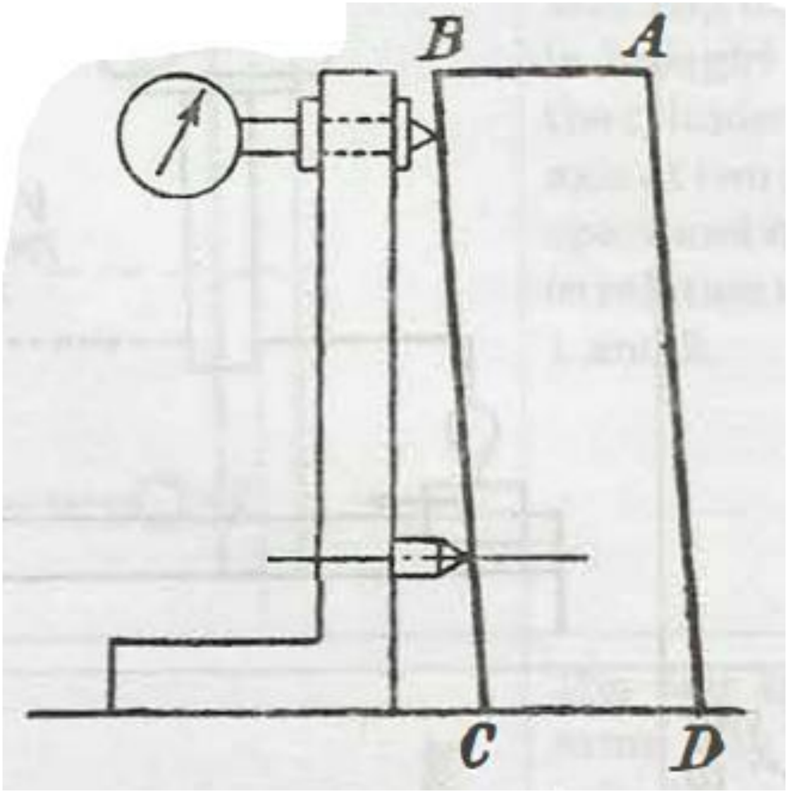
Axis being the axis of rotation.

First reading is taken by making the feeler of the dial indicator to touch on a V-block resting on two intersecting plane surfaces. (The dial indicator is mounted on the spindle). The second reading is noted by rotating the spindle along with dial by 180° arid moving the V-block so as to bring the feeler into contact with the same point on the block.



In this method, means are also available to produce and measure parallel surfaces by some form of grinder and a comparator respectively.





The height of the indicator is adjusted such that it makes contact near the top of the side of the square block. The block is then placed against the knife edge as shown in Figure 7.21

- If two sides **AD** and **BC** are truly parallel then the two readings will be same for true right angle

- In case the faces are not exactly at right angles, then the two readings will be equally above and below the reading for a true right angle.

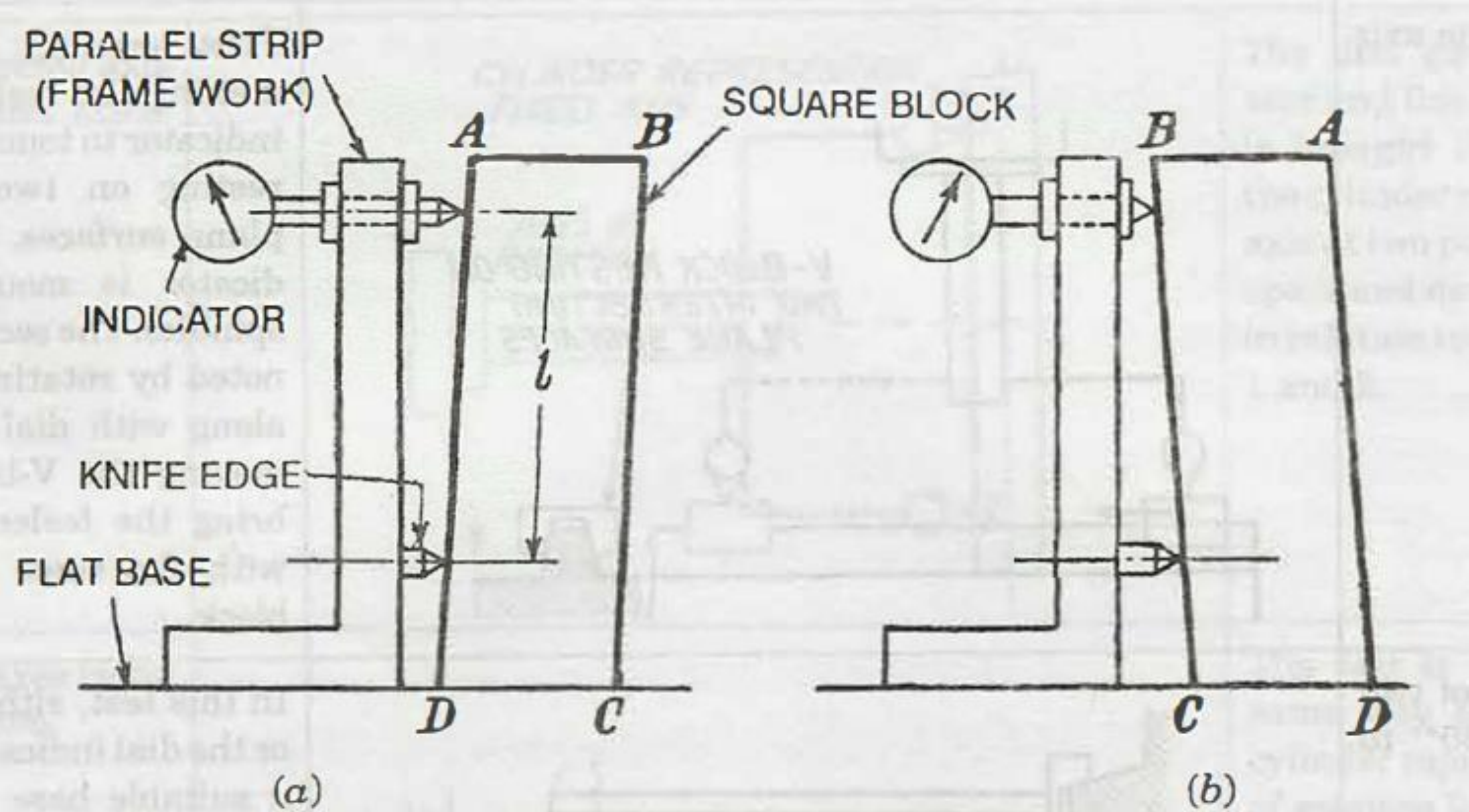


Fig. 7.21. Squareness testing by indicator method.

- Thus the differences of two readings is double the error in squareness of work over the length ‘L' between the two contact marks.

Engineer's Square Tester.

Its design is also devised by N.P.L. It consists of a bar or a tilting frame having a pair of hardened and ground steel cylinders of precisely the same size as shown in Figure

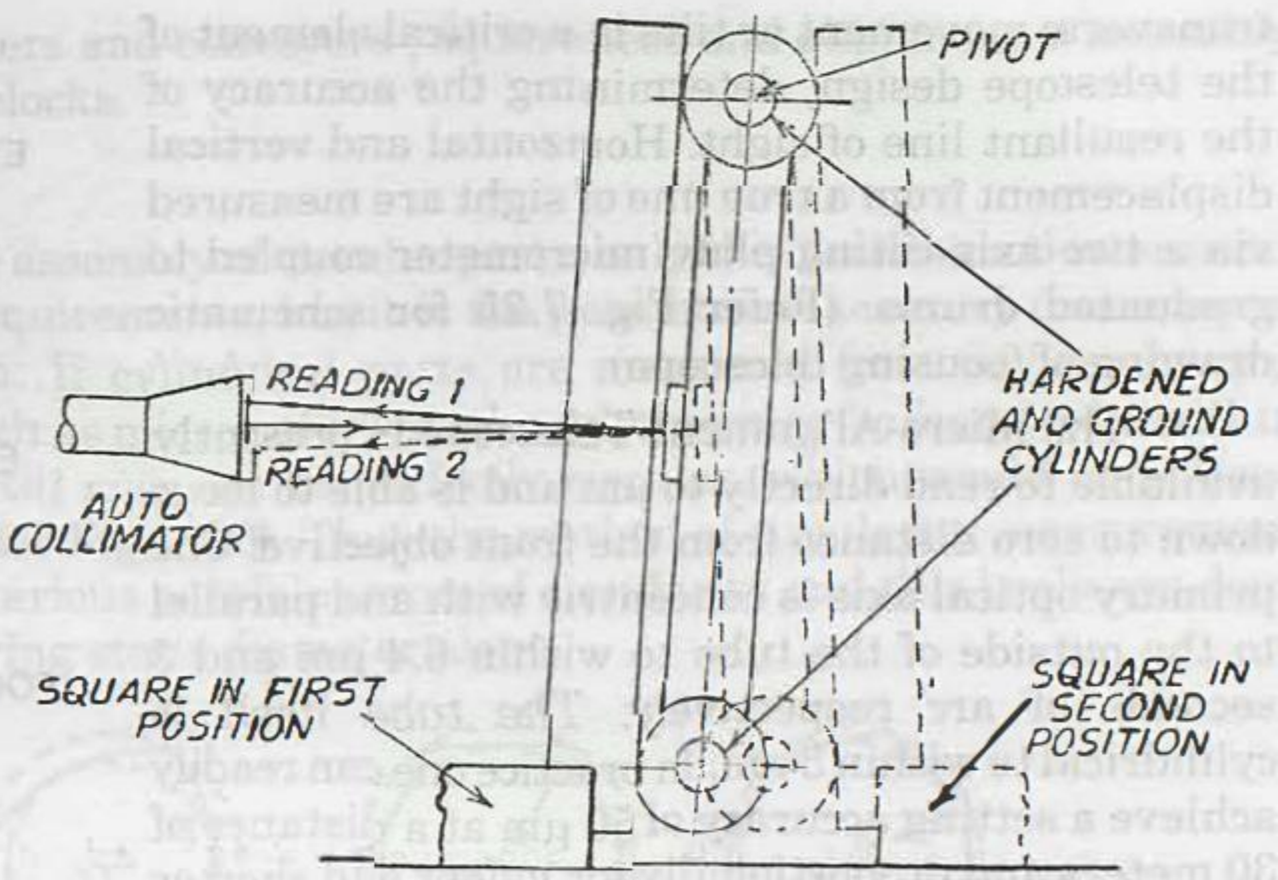
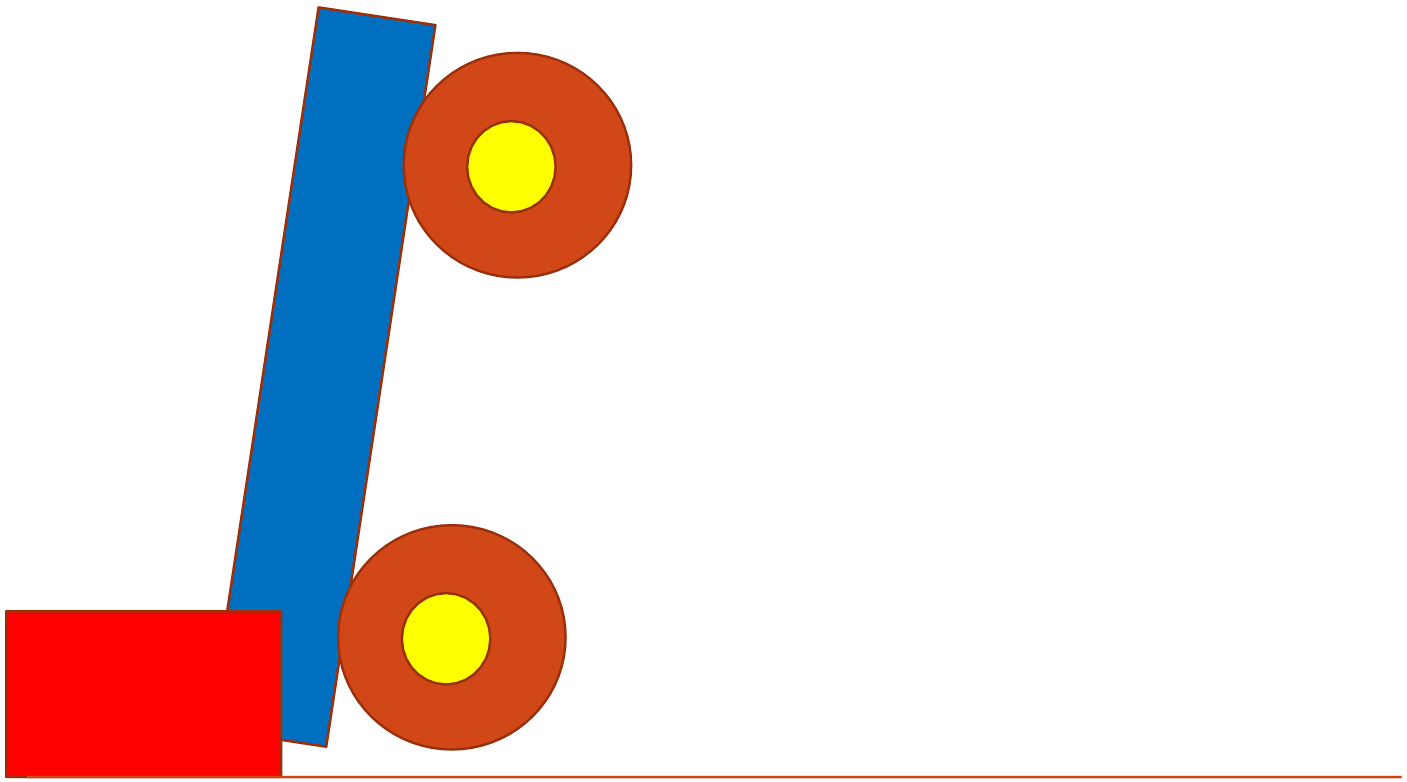


Fig. 7.23. Testing squareness with engineer's square tester.

- A plane reflector is mounted upon the bar and the instrument is set up on a flat reference plane of suitable degree of accuracy.
- The square is then placed on the same flat reference plane and the two cylinders just made to touch the blade of the square as shown in Fig. 7.23 and reading of auto-collimator noted down.



- The square as then placed on the other side as shown and again the bar so tilted such that the two cylinders just touch the blade of square and again reading in auto-collimator is noted down.
- Then half the difference in the two readings gives the angular error in the squareness of the square.

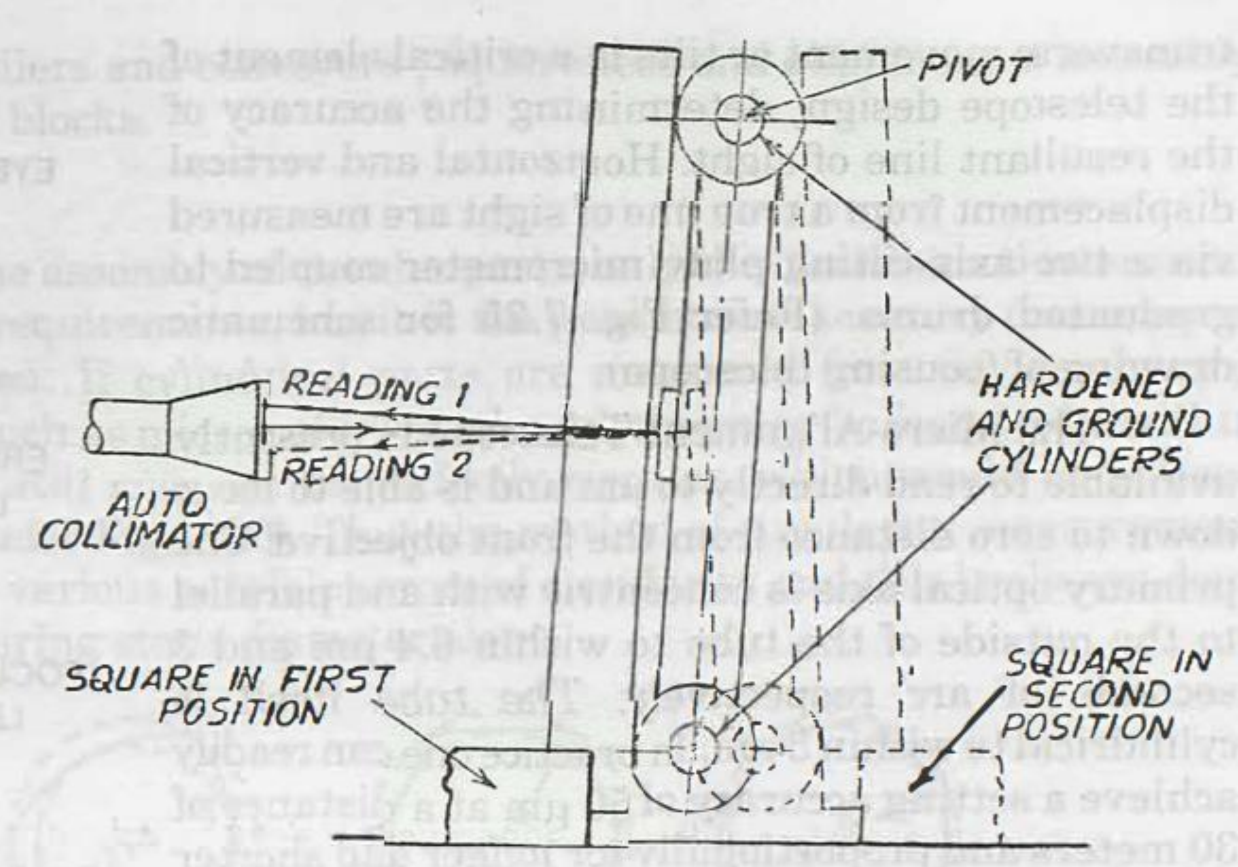
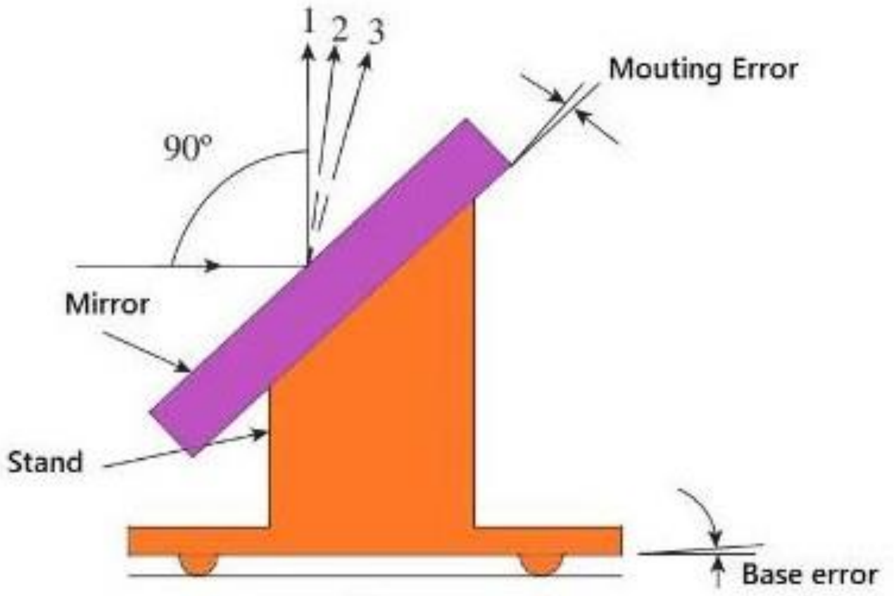


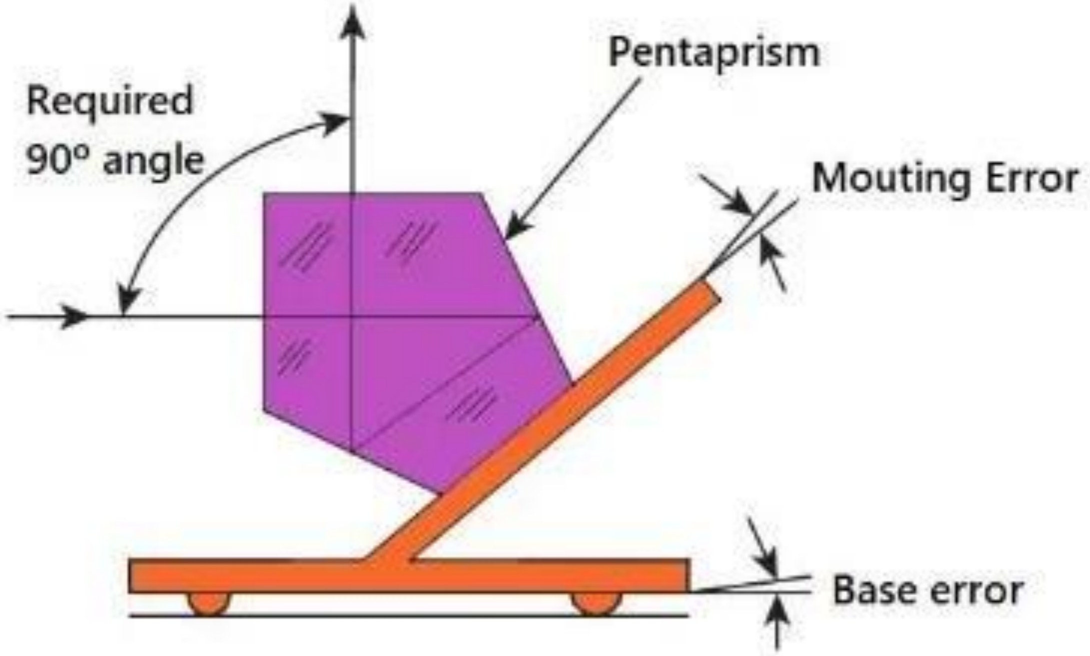
Fig. 7.23. Testing squareness with engineer's square tester.

- In order to check whether two machined surfaces are exactly at right angles to each other or not, the use of optical square and the auto-collimator can also be made

Optical Tests for Squareness using autocollimator



(Mirror arrangement)
1 – Reflected ray without errors
2 – Reflected ray due to mounting error
3 – Reflected ray due to base error

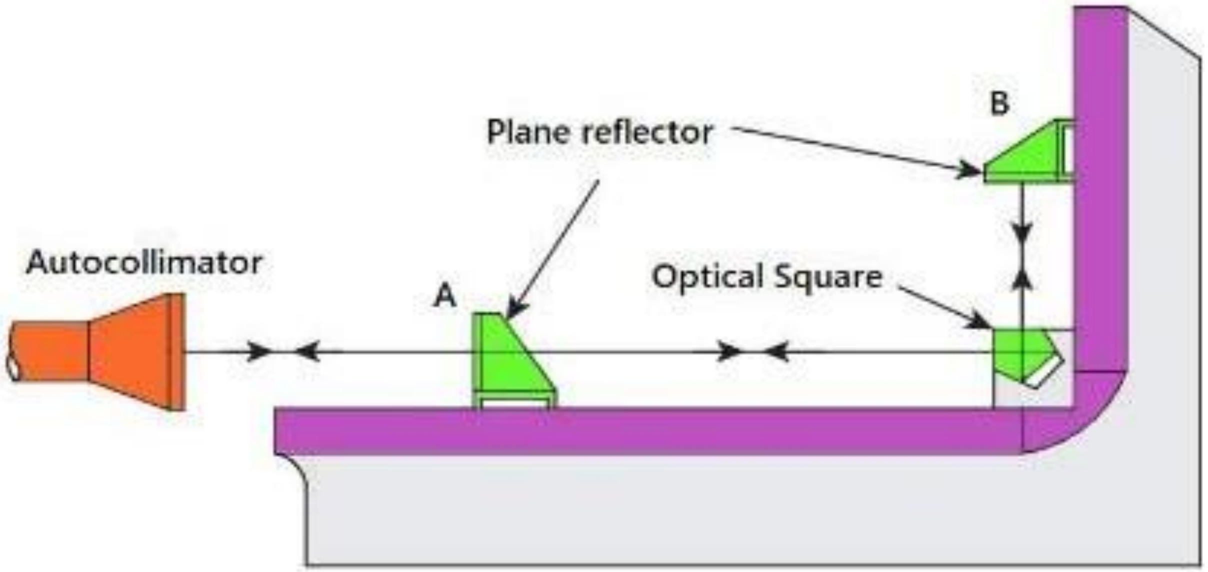


Optical square

Optical Tests for Squareness using autocollimator

Squareness of any two machined surfaces can be easily checked by using the auto-collimator.

- The axis of the incident beam from the autocollimator forms the measuring datum.
- An optical square is utilised for turning the incident bean through exactly 90° .

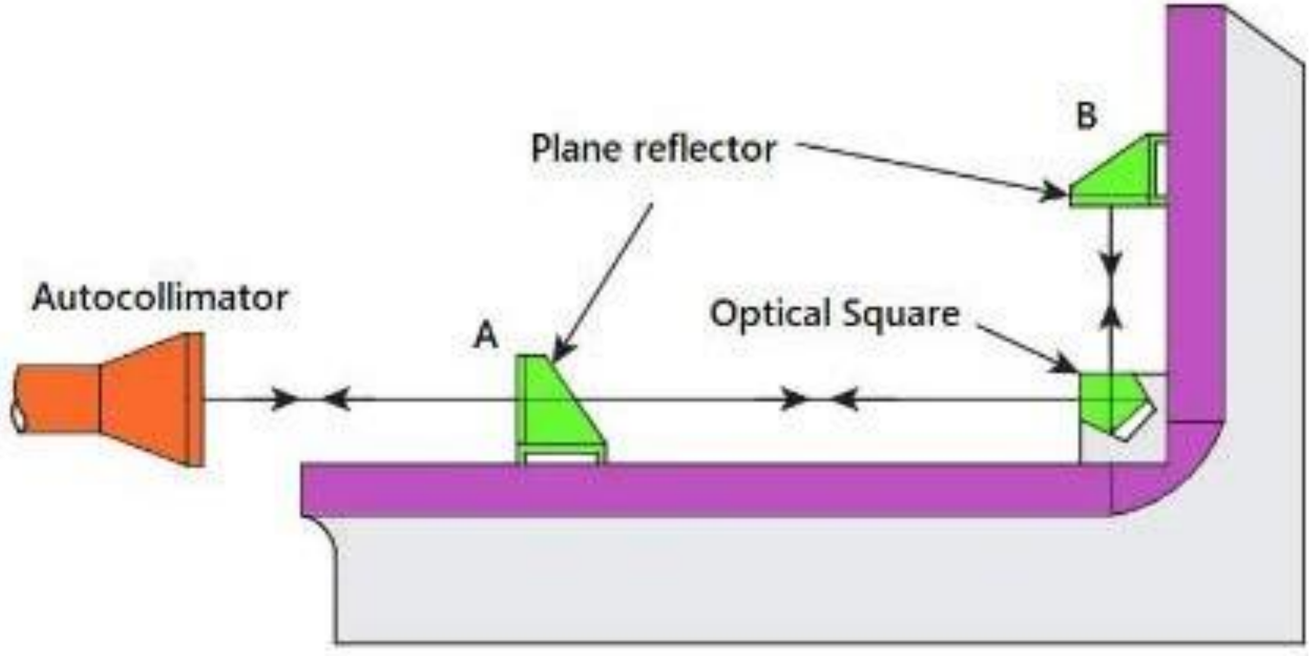


Use of an optical square to test squareness

- In this test, it is assumed that the two surface faces are perfectly straight.
- A stainless steel mirror block with a flat base is used for the horizontal surface for aligning the collimator with the surface.

Optical Tests for Squareness using autocollimator

A reading is thus taken in collimator at position A (Figure 7.24). The mirror with base is then transferred to the vertical surface and the optical square placed in the angle as indicated.



Use of an optical square to test squareness

Another reading is then taken in position B. The two auto-collimator readings of the two mirror positions will indicate whether the machined surfaces are accurately at right angles, if not the reading will show the direction and amount of error.

ANGULAR MEASUREMENTS

- Angular measurements are frequently necessary for the manufacture of interchangeable parts.
- The ships and aeroplanes can navigate confidently without the help of the sight of the land, only because of precise angular measurement.
- Precise angular measuring devices can be used in astronomy to determine the relation of the stars and their approximate distances.

The relationship between the **radius** and **arc of a circle**. It is called as radian.

Radian is defined as the angle subtended at the Centre by an arc of a circle of length equal to its radius. It is more widely used in mathematical investigation.

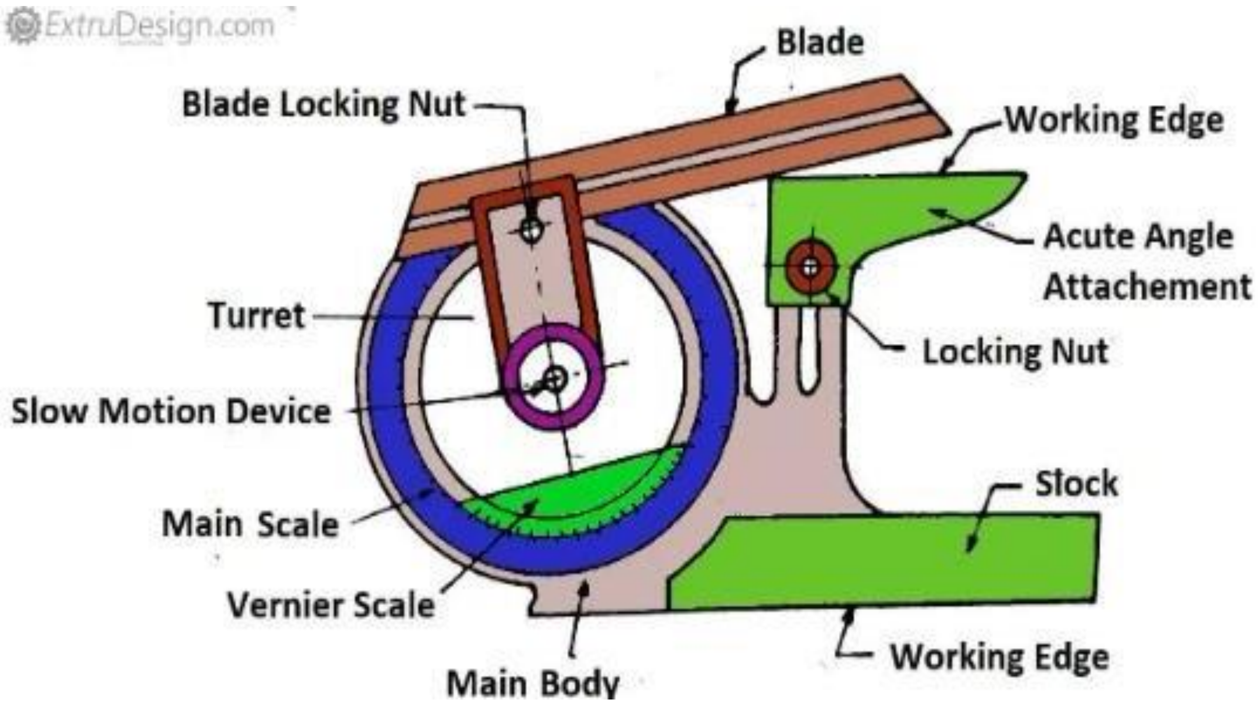
2π radians = 360° ,
1 radian= 57.2958 degrees.

INSTRUMENTS FOR ANGULAR MEASUREMENTS

There are many instruments which can be used for measuring the angles.-The selection of an instrument to be used for angular measurement depends upon the component and the accuracy of measurement required

Vernier Bevel Protractor

Bevel Protractors are the Angular measuring devices. Vernier Bevel protractor is the simplest angular measuring device which is having a Vernier Scale(Similar principle as the [Vernier Caliper]along with the acute angle attachment.



Vernier Bevel protractor consist of the following components.

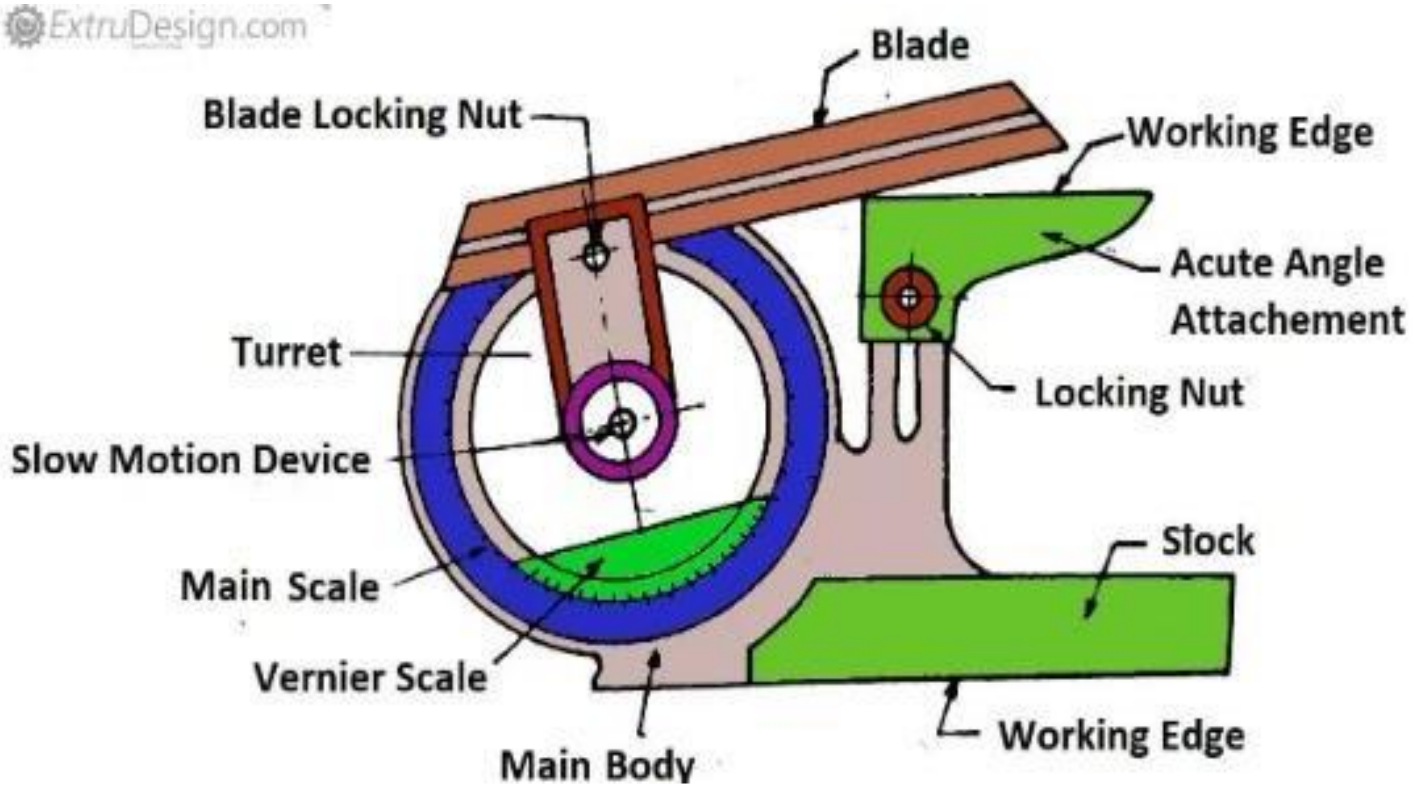
1.Main body

2.Base plate stock

3.Adjustable blade

4.Circular Plate with graduated vernier scale divisions.

1.Acute angle attachment



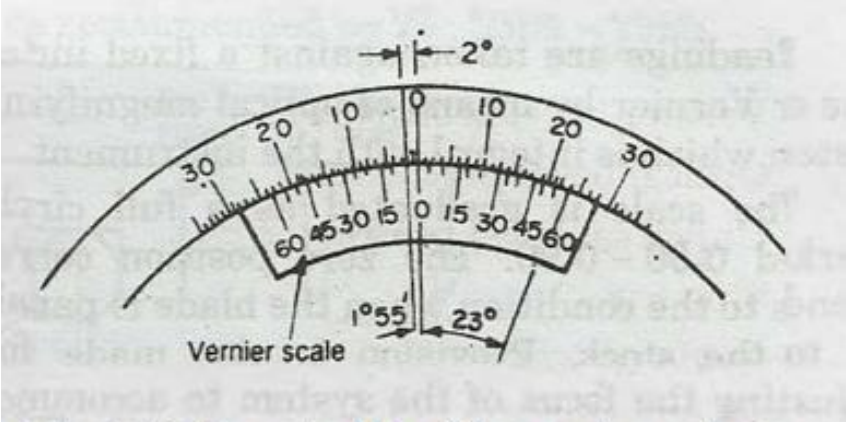
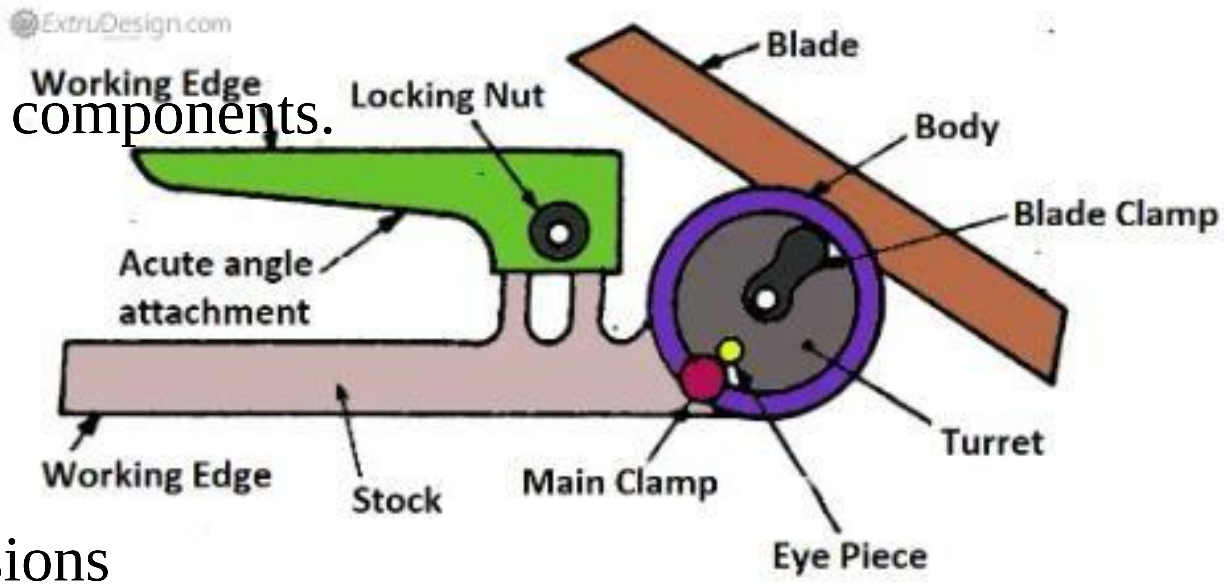


Fig. 3.46. The principle of the vernier protractor

Optical Bevel Protractor

Optical Bevel protractor consists of the following components.



1.Main body

2.Base plate stock

3.Adjustable blade

4.Circular Plate with graduated Vernier scale divisions

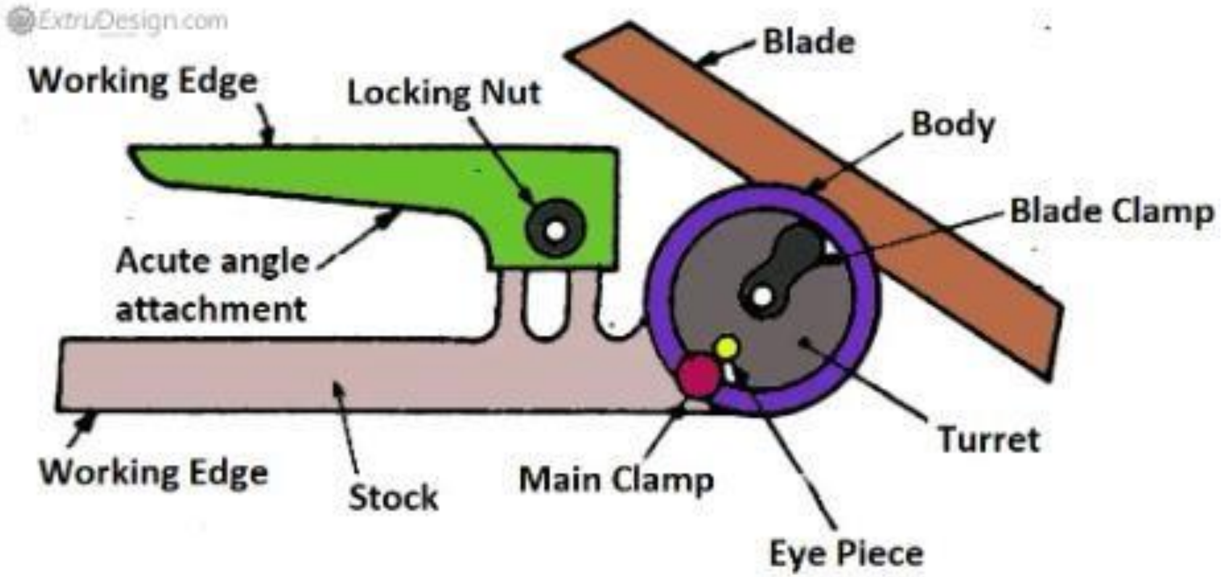
5.Acute angle attachment

6.Optical Magnifying device (Eyepiece)

- Optical bevel protractor is a recent development of the Vernier bevel protractor. By using this instrument it is possible to take readings upto approximately 2 minutes of an arc.

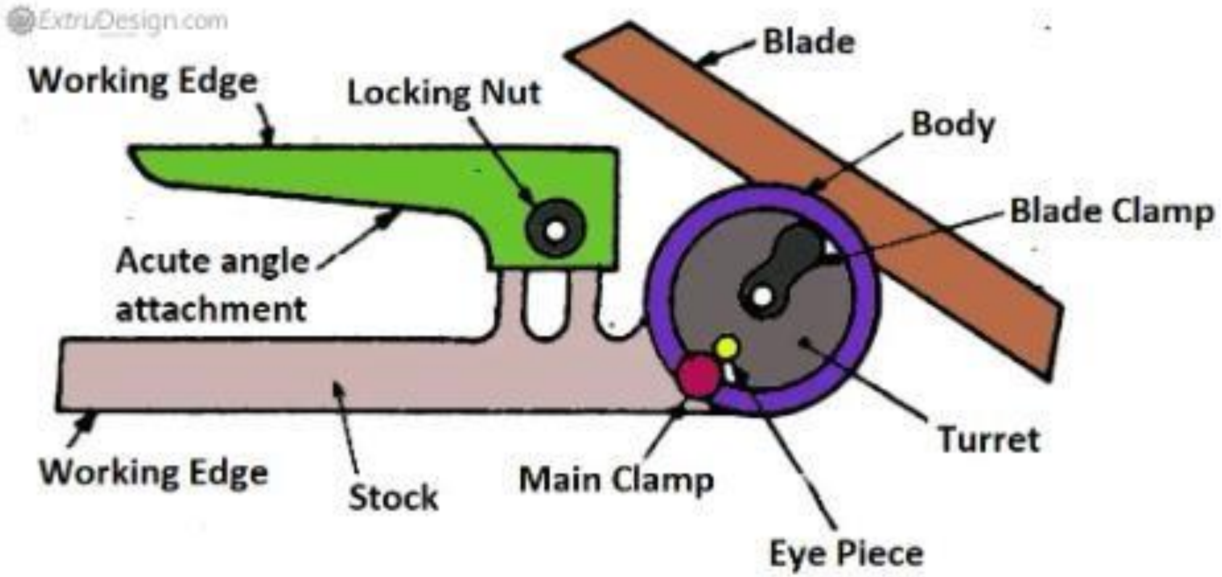
Optical Bevel Protractor

- The base plate(Stock) consisting of the Working edge will be mounted on the Main body.
- And the Acute angle attachment is also mounted on the main body.



- This acute angle attachment can be readily attachable/detachable with the Locking Nut.
- A circular plate having a vernier scale in it, also mounted on the Main body frame. (The divisions on the vernier scale in the optical bevel protractor are very close than The divisions on the vernier scale in the Vernier bevel protractor.

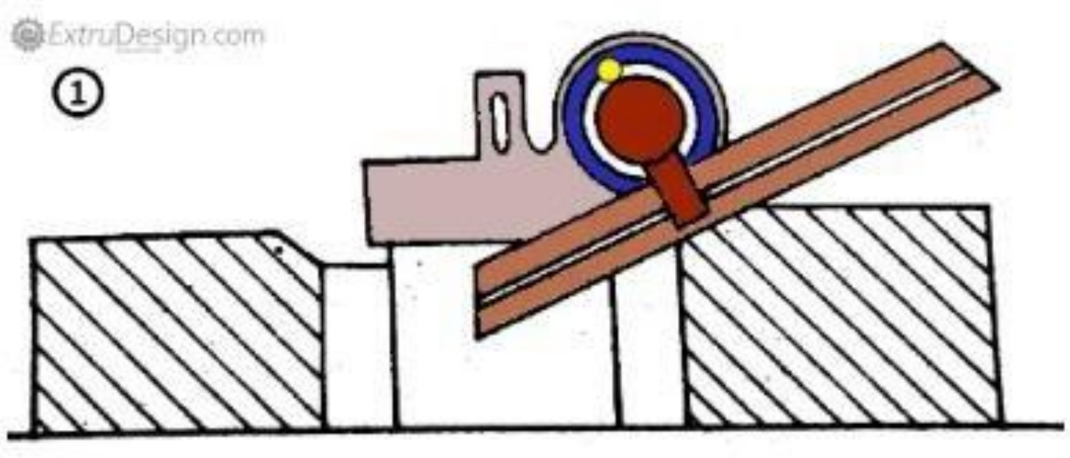
- There is an Optical Magnifying system (EyePiece) which helps to read the reading on the vernier scale in a more efficient way.



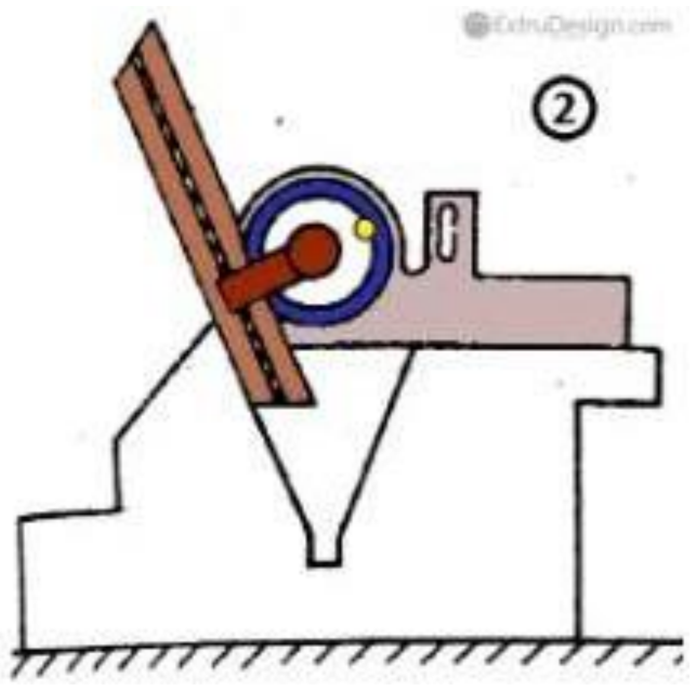
- This circular plate is carrying an adjustable blade which can travel along its length and locked at any position with the help of the blade locking nut.
- The adjustable Blade one end is beveled at angles 45° and the other end is beveled at 60°.
- This Main body frame itself having a graduated scale called the main scale.
- The circular plate can rotate freely on the main body.
- There is a slow-motion device which helps to control the rotation of the circular plate on the main body.

Working Principle of Optical Bevel Protractor

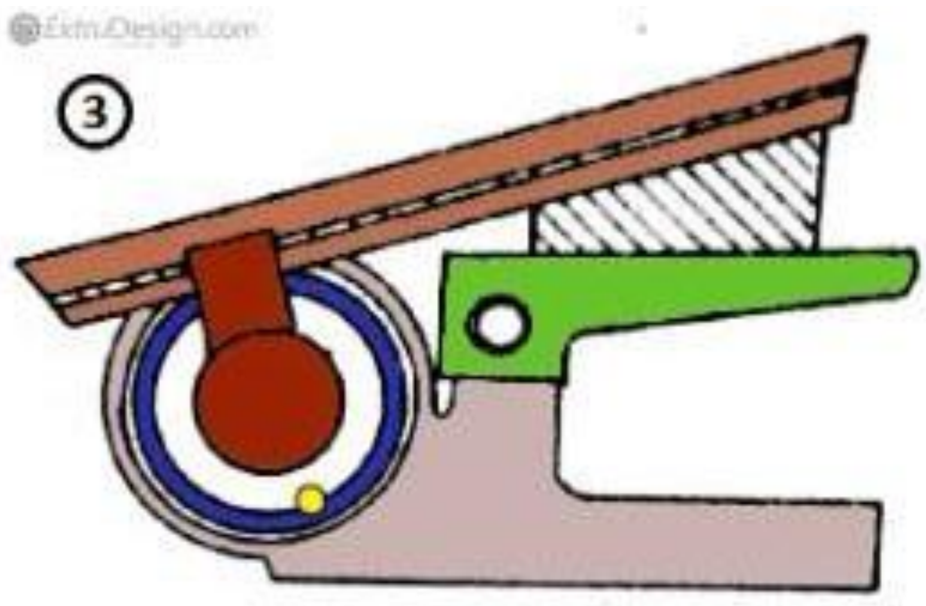
1. As the Base Plate (Stock) acts as one of the working edges, and the other working edge will be the blade which is held on the circular plate. as you can see the some of the sample positions of the Optical bevel protractor in action.



Working Principle of Optical Bevel Protractor

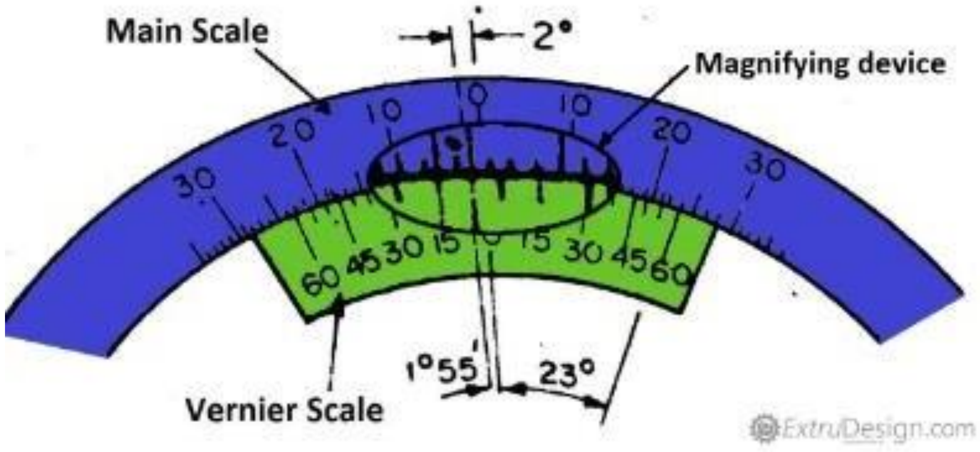


2. This Adjustment Blade can be rotated along with the circular plate on the main body.



3. Which means the vernier scale on the circular plate will be rotated on the Main scale which is graduated on the Main body as shown in below.

Working Principle of Optical Bevel Protractor



4. The Vernier scale has 12 divisions on each side of the centre zero. (It means there are 24 divisions on the vernier scale)

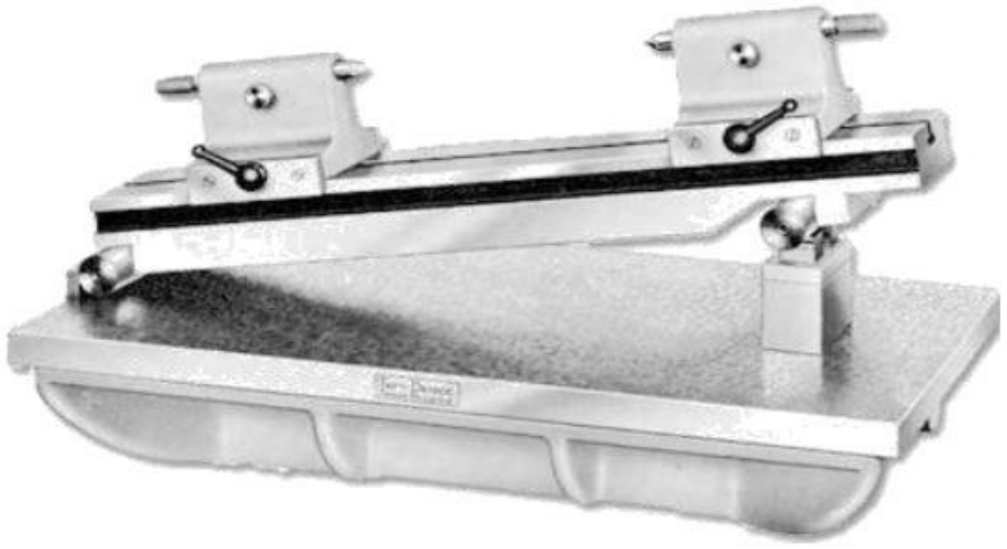
Sine Bar

Sine bar is a precision instrument used along with slip gauges for the measurement of angles sine bar is used:

(i) to measure the angles very accurately

(ii) to locate the work to a given angle within very close limits.

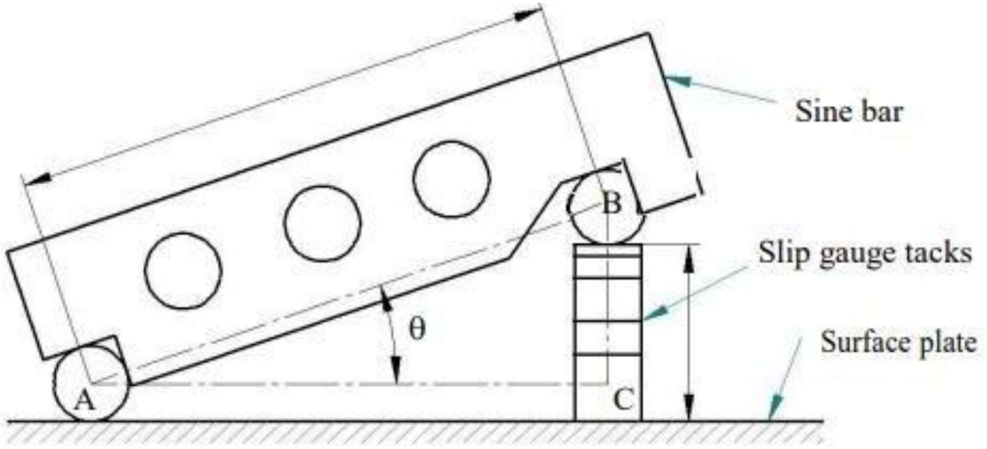
Sine Bar



- It consists of a steel bar and two rollers. The sine bar is made of high carbon, high chromium corrosion resistant ·steel, suitably hardened, precision ground and stabilised:
- The rollers are of accurate and equal diameters. They are attached to the bar at each end.
- The axes of these rollers are . parallel to each other and also to the upper surface of the bar.
- The normal distance between the axes of the rollers is exactly 100 mm, 200 mm or 300 mm.

Sine Bar

- When the rollers are brought in contact with a flat surface, the top of the bar is parallel to the surface.
- The various parts are hardened and stabilized before grinding and lapping. All the working surfaces of the bar and the cylindrical surfaces are fined to surface finish of O. 2 μm Ra value or better.



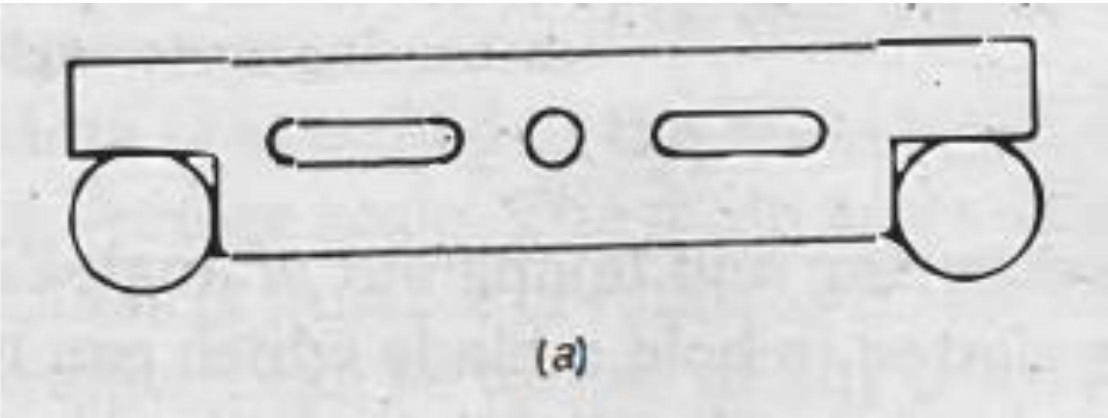
Sine bars are graded as A grade or B grade sine bar.

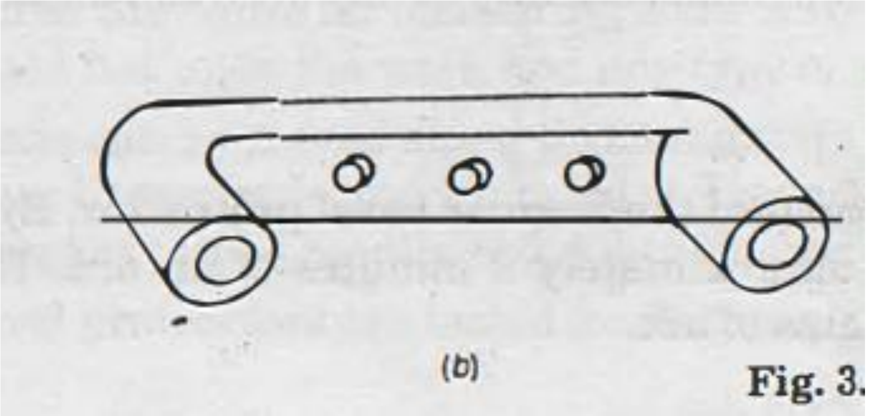
A grade sine bar are made with an accuracy of 0.01 mm/m of length, and

B grade sine bars with an accuracy of0.02 mm/m of length.

Sine Bar

The sine bars are available in several designs for different applications.

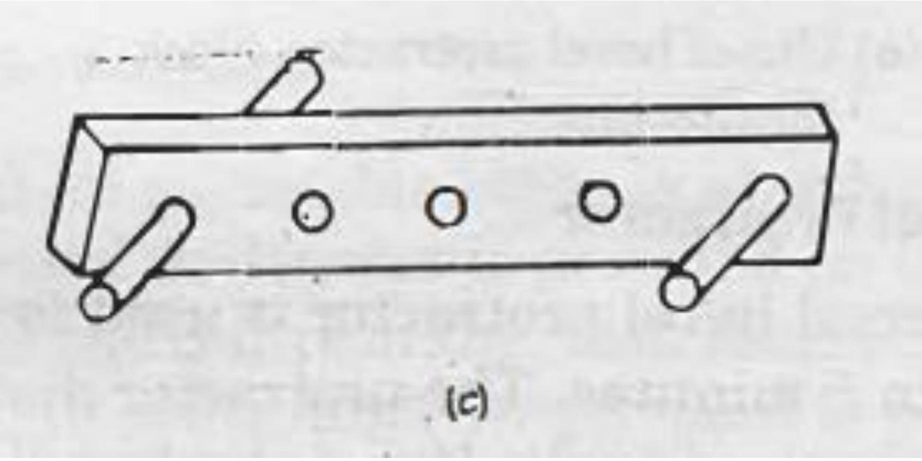




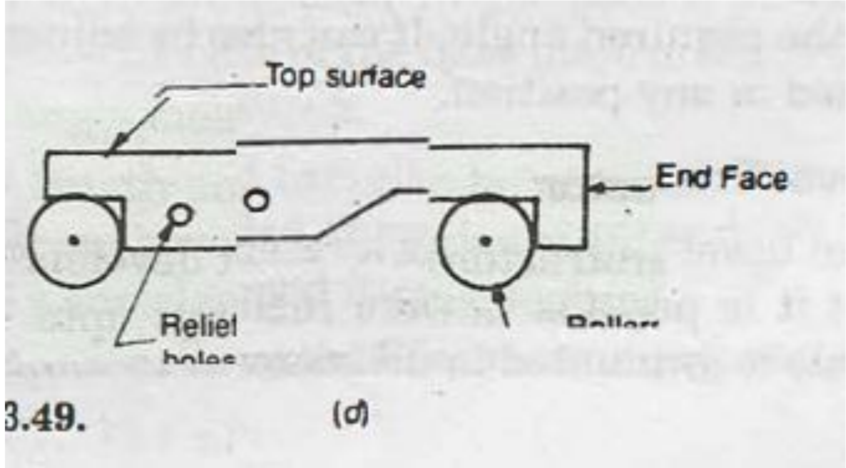
(a) form in which the rollers are so arranged that their outer surfaces on one side are level with the plane top surface of the sine bar.

(b) shows a sine bar with hollow rollers which outside diameter is equal to the width of sine bar. It is useful in instances where the width of the bar enters into calculation of work height.

Sine Bar

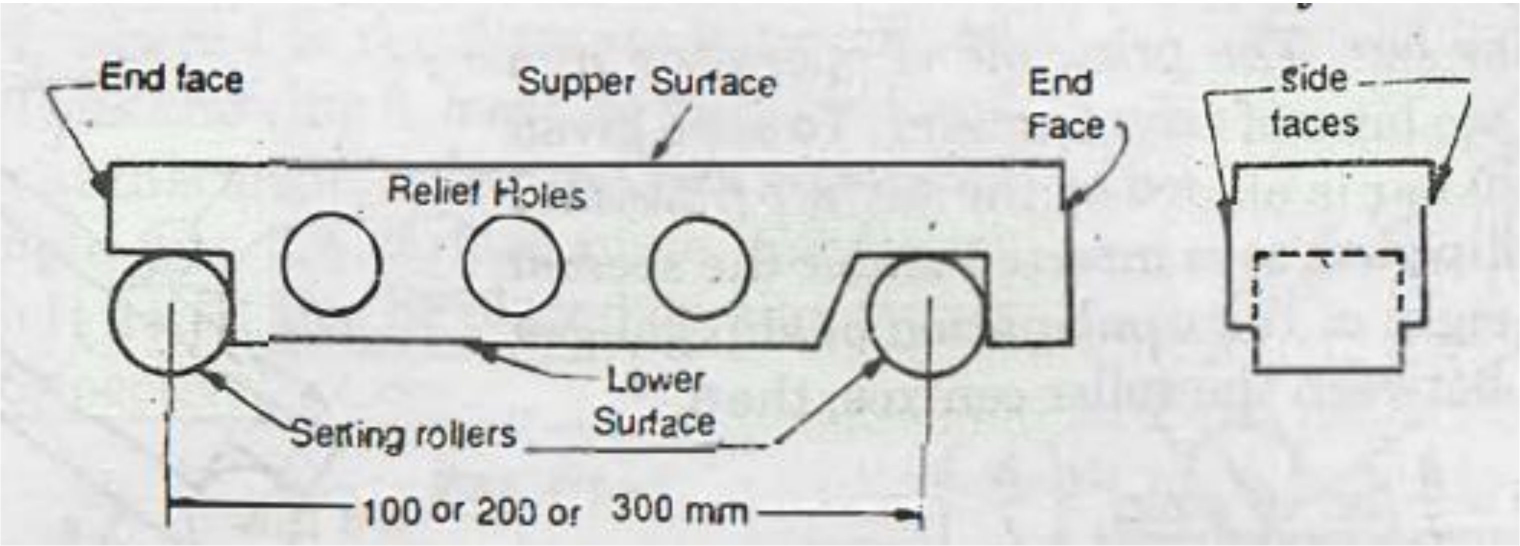


(c) shows a sine bar with pins on both sides. This is used where the ordinary sine bar cannot be used on the top surface due to interruption.

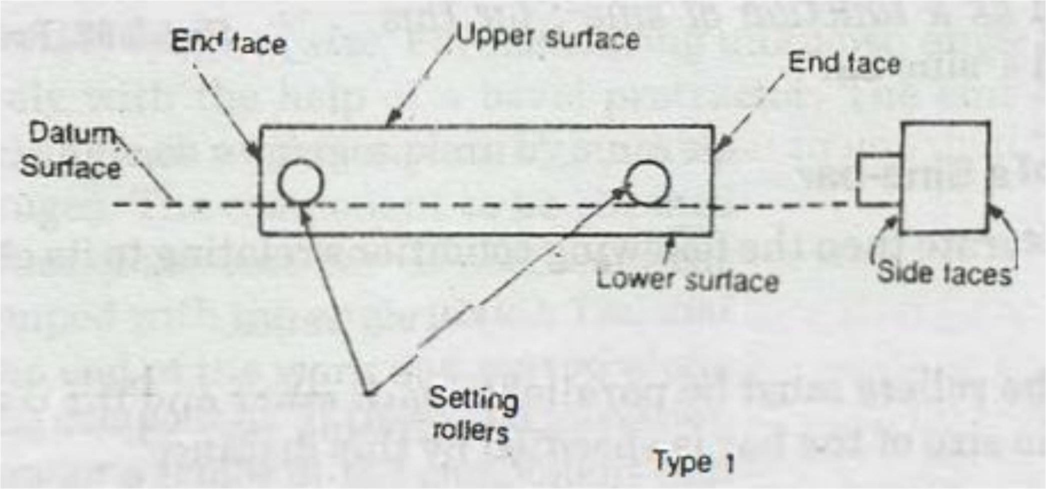


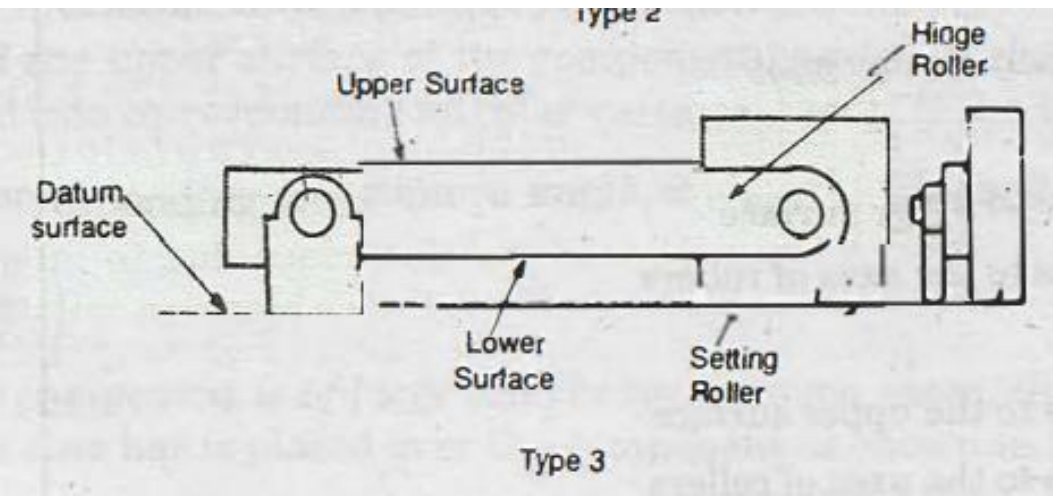
(d) shows a sine bar which is generally preferred as the distance between rollers can be adjusted exactly.

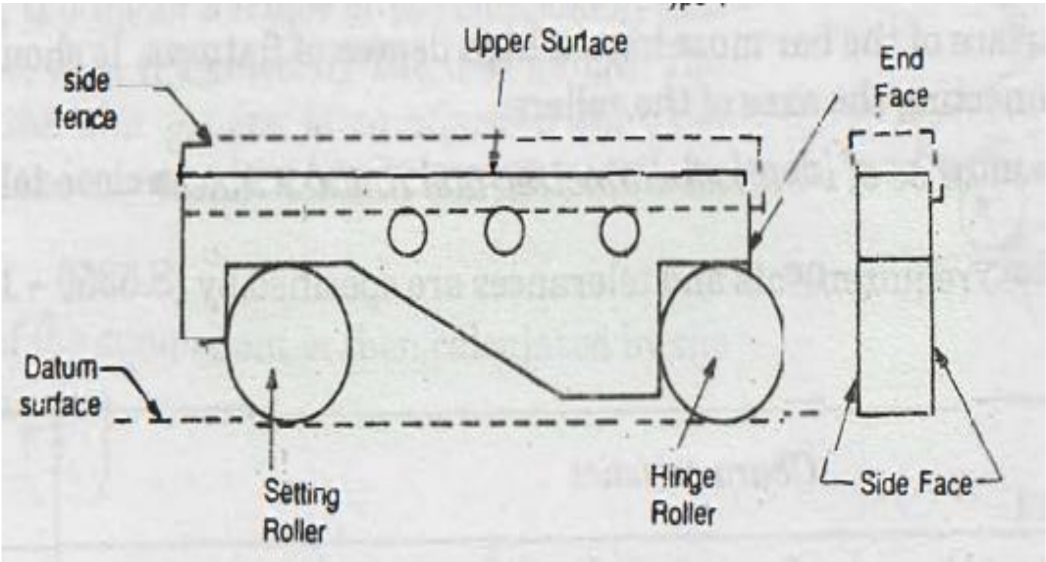
Sine Bar

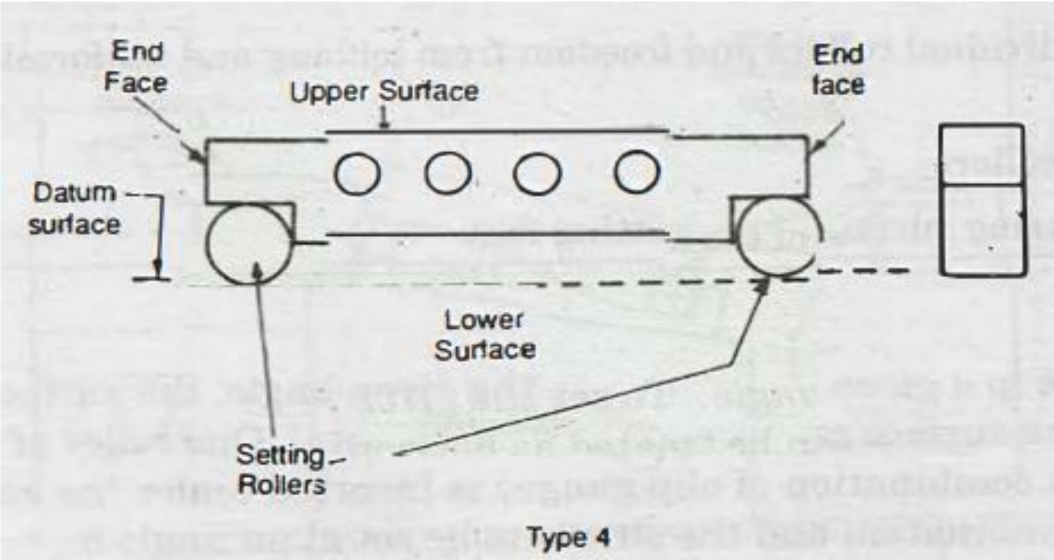


This form can be set to a steep angle without the slip gauges following the underside of the bar, but the accuracy of setting decreases with steep angles. The holes are drilled in the body of the sine bar to make it lighter and to facilitate handling shows the various types of sine bars as recommended by BS: 3064









Principle of Sine bar.

The principle of operation of a sine bar is based on the laws of trigonometry.

- To set a given angle, one roller of the bar is placed on the surface plate and the combination of slip gauges is inserted under the second roller.
- If '**h**' is the height of the combination of slip gauges and '**L**' the distance between the roller centres, then

$$\sin\theta = \frac{h}{L} \quad or \quad \theta = \sin^{-1}\left(\frac{h}{L}\right).$$

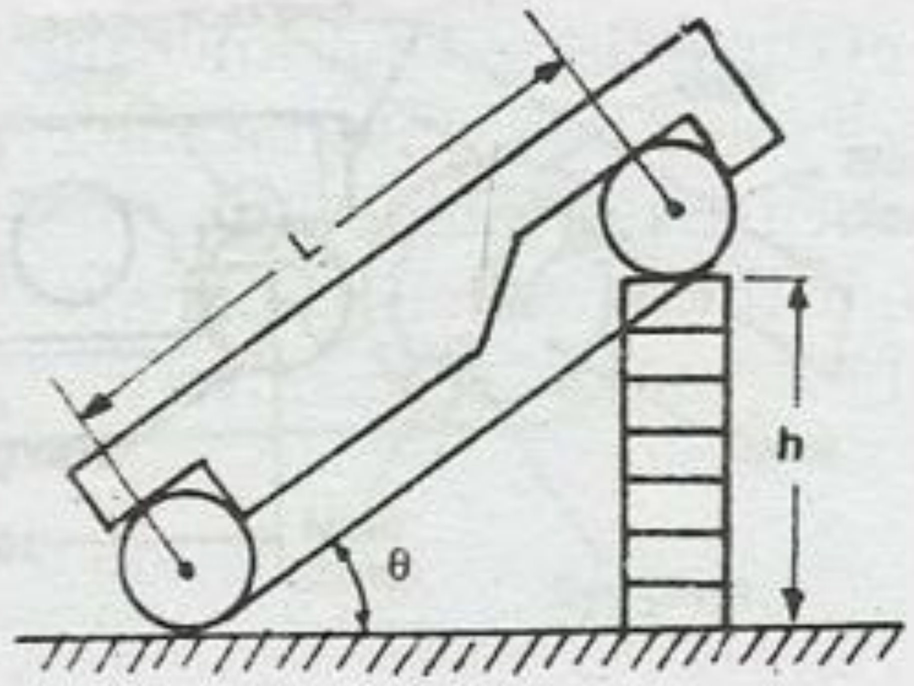
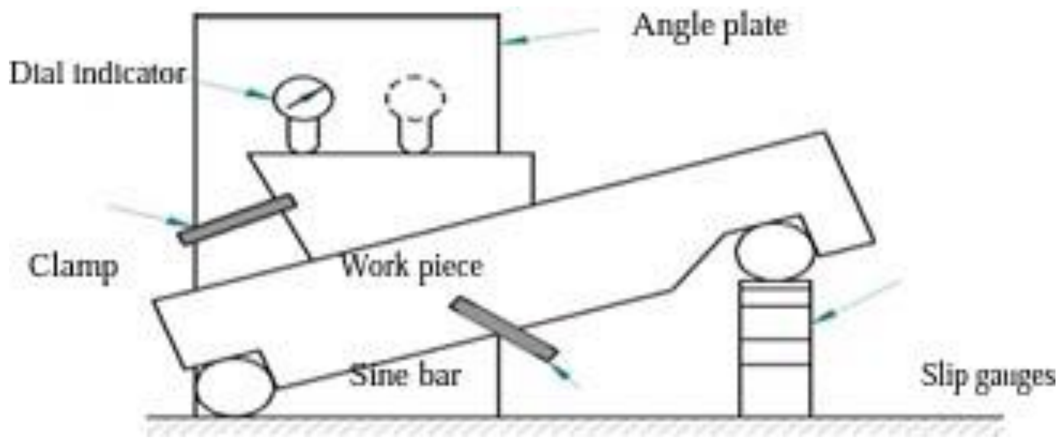


Fig. 3.52. Principle of sine bar

Principle of Sine bar.

For checking unknown angles of a component, a dial indicator is moved along the surface of work and any deviation is noted. The slip gauges are then adjusted such that the dial reads zero as it moves from one end to the other.



Accuracy Requirements of a Sine-bar

If a sine bar is to be accurate then the following conditions relating to its constructional features must exist:

(1)The axes of the rollers must be parallel to each other and the centre distance L, must be known. The size of the bar is specified by this distance.

(2) The top surface of the bar must have a high degree of flatness. It should be parallel to a plane connecting the axes of the rollers.

(3) The rollers must be of identical diameters and round within a close tolerance.

Limitations of Sine Bars

(i)Sine bar is fairly reliable for angles less than 15° , and becomes increasingly inaccurate as the angle increases. It is impractical to use sine bars for angle above 45° .

(ii) It is physically clumsy to hold in position.

(iii) Slight errors of the sine bar cause larger angular errors.

(iv) A difference of deformation occurs at the point of roller contact with the surface plate and to the gauge blocks.

(v) The size of parts which can be inspected by sine bar is limited.

Sources of Error in Sine Bars

The different sources of errors in angular measurement by a sine bar are

1. Error in distance between roller centres.
2. Error in slip gauge combination used for angle setting.
3. Error in parallelism between the gauging surface and plane of roller axes.
4. Error in equality of size of rollers and cylindrical accuracy in the form of the rollers.
5. Error in parallelism of roller axes with each other.
6. E:rror_in flatness of the upper surface of the bar

Angle Gauges.

Angle gauges were developed by Dr. Tomlinson in 1941, which enable any angle to be set to the nearest 3". These are pieces of hardened and stabilised steel.

The measuring faces are lapped and polished to a high degree of accuracy and flatness.

They are 75 mm long and 16 mm wide and are available in two sets.

- One set consists of 12 - pieces and a square block, in three series of values of angle viz.

  1 ° , 3° , 9° , 27° and 41°

  1', 3', 9' and 27' and

  6", 18" and 30 "

Another set contains 13 pieces and a square block

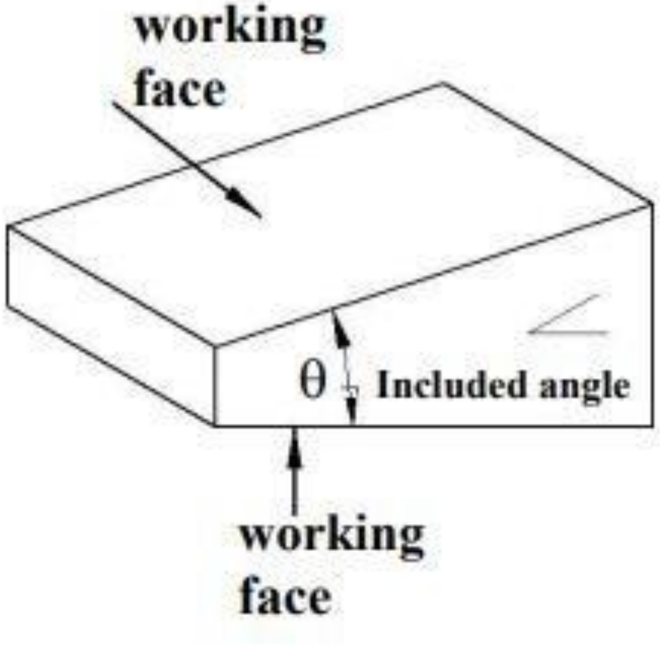
1 ° , 3° , 9° , 27° and 41°

1’3', 9', 27' and

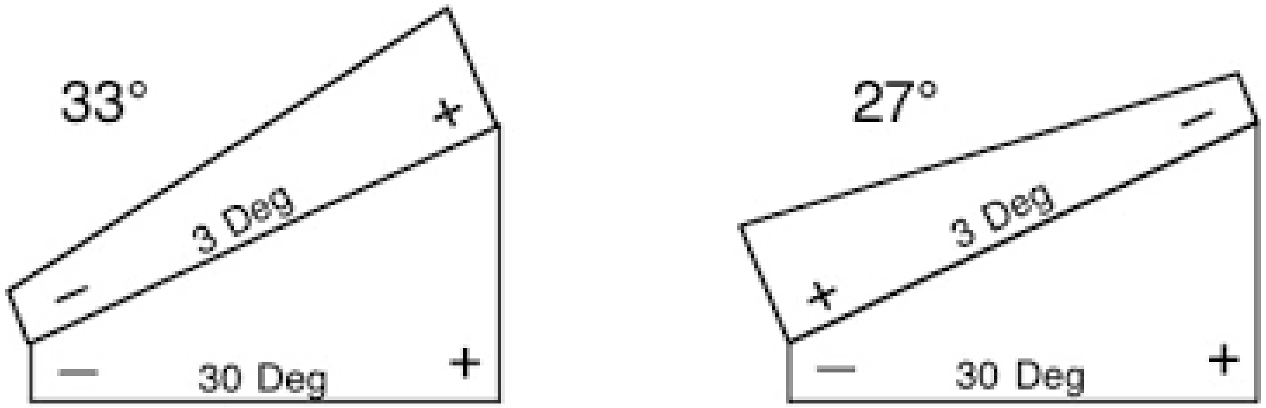
3" 6" 18" and 30 "

- Each angle gauge is accurate to within one second and is marked with. engraved V which indicates the direction of the inclined angle.

- These gauges, together with a square block can be so wrung that any angle between 0 ° to 360° can be set.
- Each angle gauge is a wedge, thus two gauges with their narrow ends together provide an angle which is the sum of the angles of the individual gauges.



Subtraction of angles is obtained when the narrow ends are opposed as shown in Figure



Addition and subtraction of angle gauges

Each angle gauge is marked with engraved V which indicates the direction of included angle.

When the angles of individual angle gauges are to be added up then the V of all should be in line and when any angle is to be subtracted, its engraved V should be in other direction.

Practical uses of angle gauges.

- Angle gauges are widely used in industries for the quick measurement of angles between two surfaces.
- A frequent use of these gauges is to check whether the component is within its tolerance angle or otherwise
- Where the angle to be measures exceeds 90° , the use of precision square becomes essential.

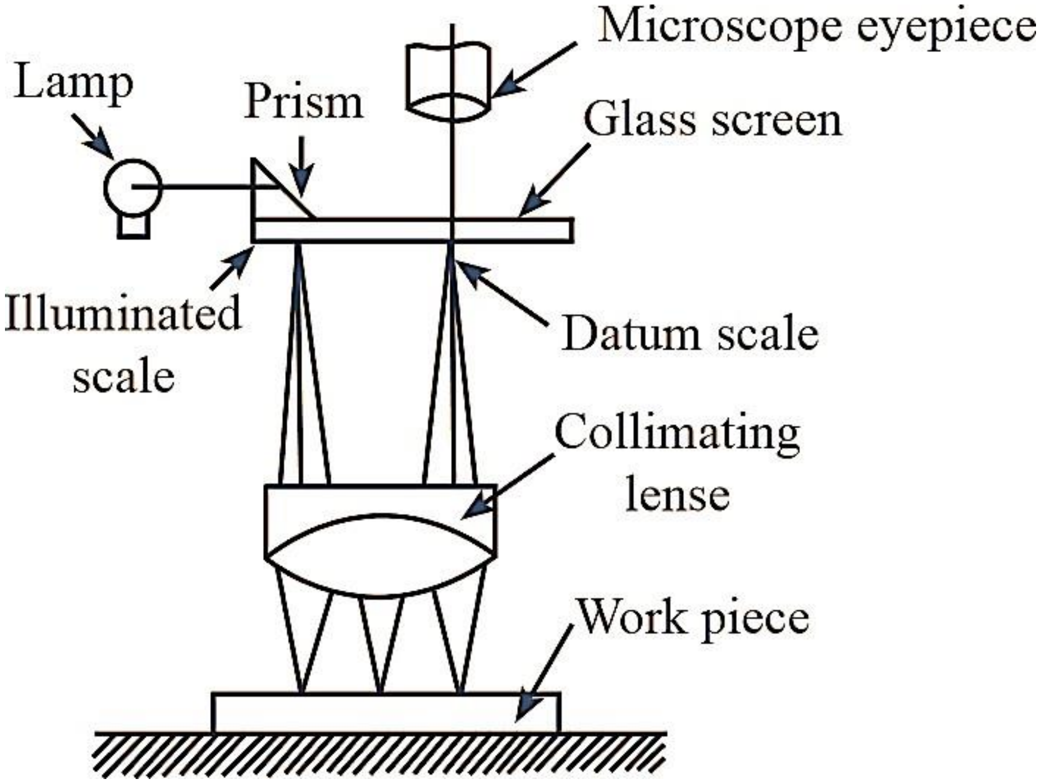
Limitations

By combining (wringing) angle gauges any angle could be made but the block formed by the combination of number of these gauges is rather bulky and eannot always be conveniently applied to work,

so they are used as reference along with other angle measuring devices.

Secondly, errors are easily compounded when angle blocks are wrung in combination.

Angle Dekkor



Angle Dekkor

- This is a type of auto-collimator. It consists of microscope, objective (collimating) lens and two scales engraved on a glass screen which is placed in the focal plane of the objective lens.
- One of the scales, called datum scale; is horizontal and fixed. It is engraved across the centre of the screen and is always visible in the microscope eye-piece.
- Another scale is an illuminated vertical scale fixed across the centre of the screen and the reflected image of the illuminated scale is received at right angles to this fixed scale,

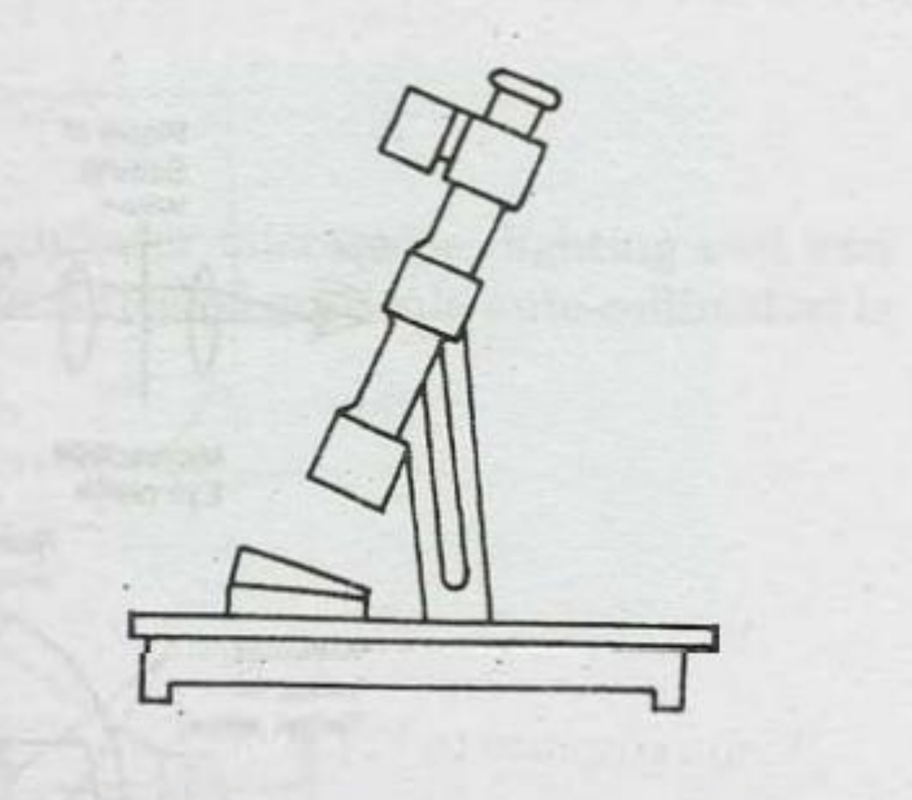
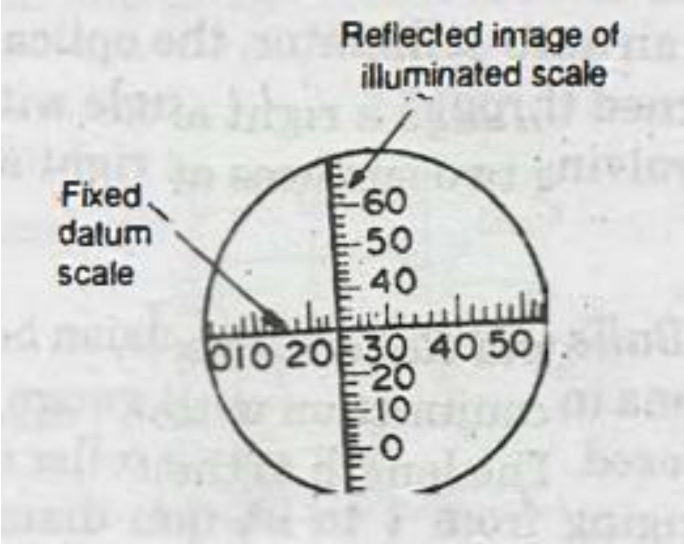


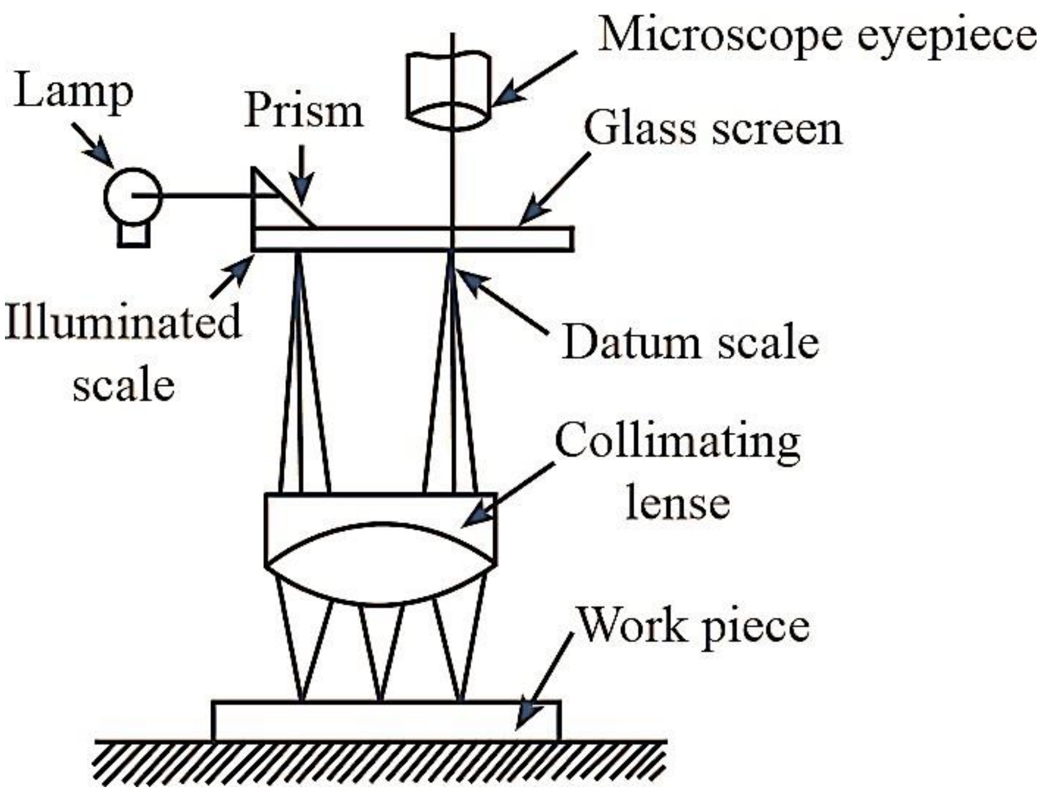
Fig. 3.67. Using the angle dekkor for the angle measurement of a component

the two scales, in the. Position intersect each other. Thus the reading on illuminated scale measures angular deviations from one axis at 90° to the optical axis, and the reading on the fixed datum scale measures the deviation about an axis mutually perpendicular to the other two.



Thus, the changes in angular position of the reflector in two planes are indicated by changes in the point of intersection of the two scales. Readings from scale are read direct to 1' without the use of a micrometer.

The whole optical system is enclosed in a tube which is mounted on a adjustable bracket. The adjustable bracket is attached to a flat lapped reflective base as Figure



COMPARATORS

A comparator is a precision instrument employed to compare the dimension of a given component with a working standard

It thus does not measure the actual dimension but indicates how much it differs from the basic dimension.

The indicated difference is usually small and hence suitable magnification device is provided to measure the difference with consistent accuracy.

Thus a comparator is an indirect type of precision instrument which

- Gives linear measurement
- works on relative measurement
- Indicates only dimensional difference in relation to the basic dimension
- has a sensing device, magnifying or amplifying system and or display system (usually scale and pointer) to provide suitable read out.

Need for a comparator

- In mass production identical component parts are produced on a very large scale. To achieve inter changeability these parts should be produced to a close dimensional tolerances. As a result, inspection is often more concerned with the dimensional variation from the standard or basic dimension of the part.
- To this extent inspection becomes a process of comparing manufactured part to the master part envisaged by the designer
- The use of vernier calliper, micrometer etc will not be feasible because of the skill involved and the time required to measure the dimension.
- Use of comparator requires little or no skill for the operator, eliminates human element for taking measurement and gives quick and highly consistent results.

Uses of Comparator

1.Laboratory Standards: Comparators are used as laboratory standards from which working or inspection gauges are set and corelated.

2.Working Gauges : They are also used as working gauges to prevent work spoilage and to maintain required tolerance at all important stages of manufacture.

3.Final Inspection Gauges : Comparators may be used as final inspection gauges where selective assembly of production parts is necessary

4.Receiving Inspection Gauges : As receiving inspection gauges comparators are used for checking parts received from outside sources.

5.For checking newly purchased gauges: The use of comparators enables the checking of the parts (components in mass production at a very fast rate.)

Essential characteristics of a good comparator

1.Robust design and construction: The design and construction of the comparator should be robust so that it can withstand the effects of ordinary uses without affecting its measuring accuracy.

2.Linear characteristics of scale: Recording or measuring scale should be linear and unifom1 (straight line characteristic) und its u1.dications should be clear

3.High magnification : The magnification of the comparator should be such that a smallest deviation in size of component can be easily detected.

4.Quick in results: The indicating system should be such that the readings are obtained in least possible time.

Essential characteristics of a good comparator

5.Versatility : Instruments should be designed that it can be used for wide range of measurements.

6.Minimum wear of contact point : The measuring plunger should have hardened steel contact or diamond to minimize wear effects. Further the contact pressure should be low and uniform.

7.Free from oscillations: The pointer should come rapidly to rest and should be free from oscillations.

8.Free from back lash: System should be free from back lash and unnecessary friction and it should have minimum inertia.

10. Adjustable Table : The table of the instrument should, preferably, be adjustable in a vertical sense.

Mechanical Comparator:

- It is self controlled and no power or any other form of energy is required.
- It employs mechanical means for magnifying the small movement of the measuring stylus.
- The movement is due to the difference between the standard and the actual dimension being checked

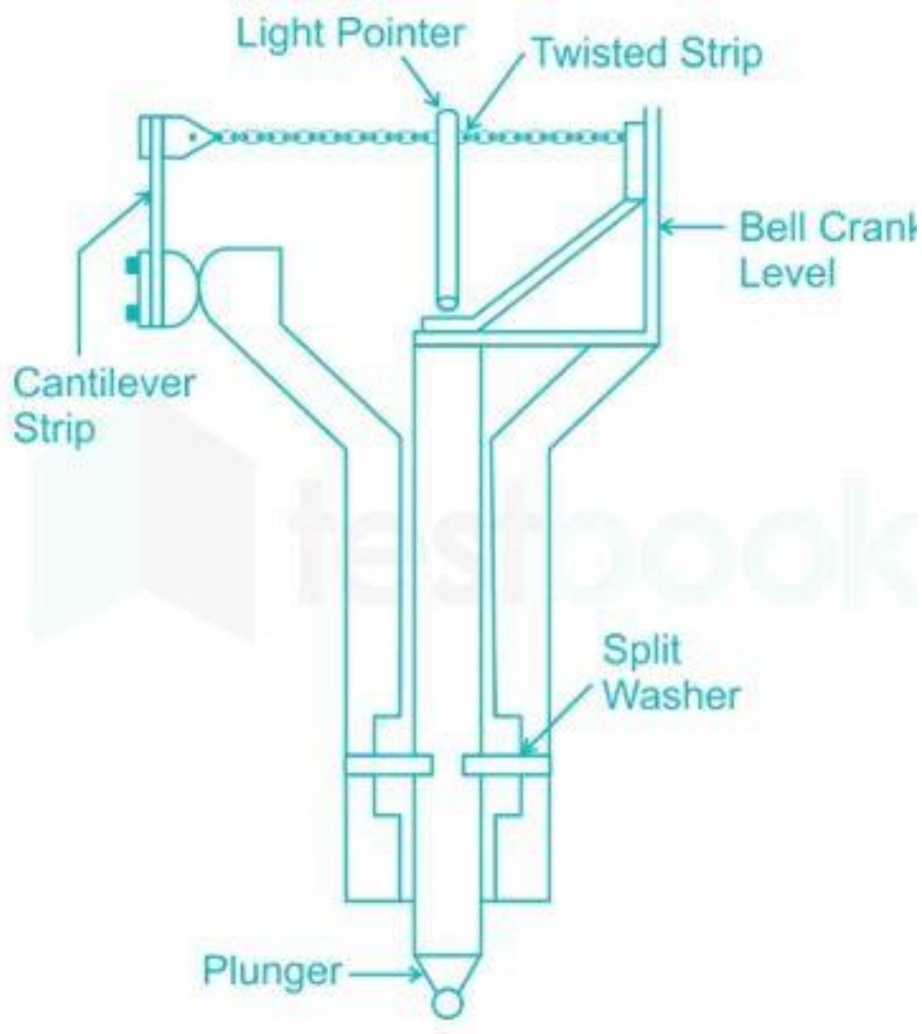
The usual magnification obtained by these comparators ranges from about 250 to 1000.

Mechanical comparators are of the following types

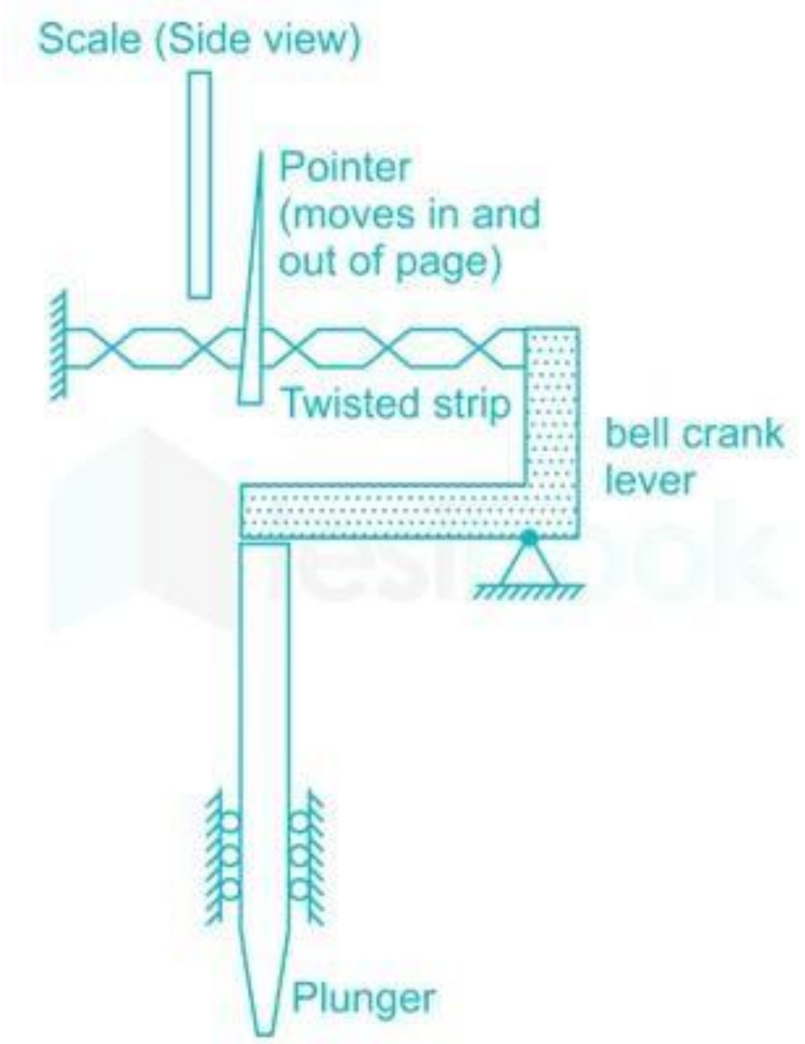
1. Dial indicator (Dial gauge)
2. Read type mechanical comparator
3. Johansson Mikrokator
4. Sigma comparator.

Johansson Mikrokator:

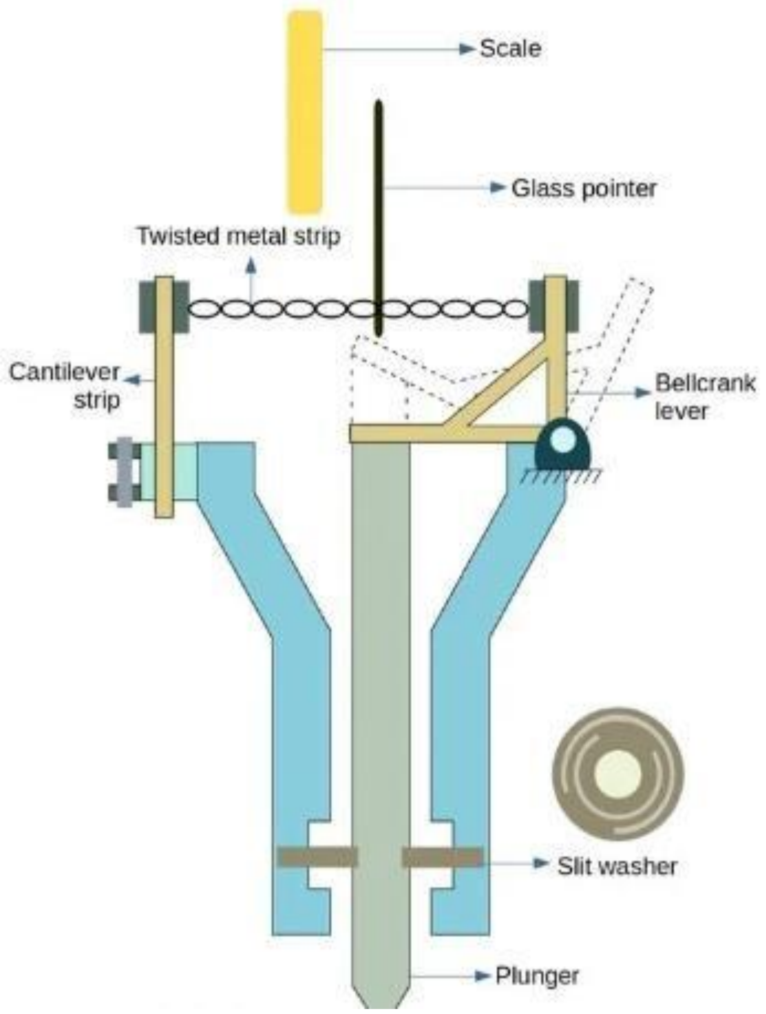
- This comparator was made by C.F. Johansson Ltd. and therefore named so.
- It uses a twisted strip to convert small linear movement of a plunger into a large circular movement of a pointer. It is therefore, also called as twisted strip comparator.
- It uses the simplest method for obtaining the mechanical magnification designed by H.Abramson which is known as **Abramson movement.**



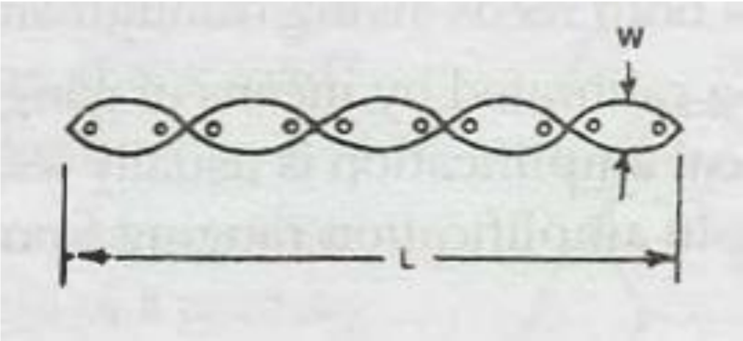
- A twisted thin metal strip carries at the centre of its length a very light pointer made of thin glass.
- One end of the strip is fixed to the adjustable cantilever strip and the other end is anchored to the spring elbow, one arm of which is carried on measuring plunger.
- The spring elbow acts as a bell crank lever. The construction of such a comparator is shown in Figure



- A slight upward movement of plunger will make the bell crank lever to rotate.
- Due to this a tension will be applied to the twisted strip in the direction of the arrow. This causes the strip to untwist resulting in the movement of the point.
- The spring will ensure that the plunger returns when the contact pressure between the bottom tip of the plunger and the workpiece is not there, that is, when the workpiece is removed from underneath the plunger.

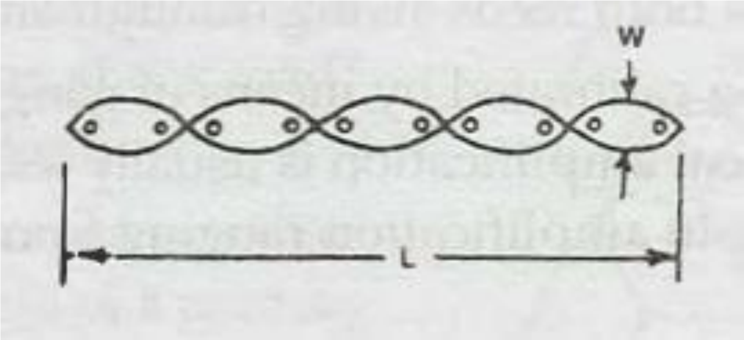


- The length of the cantilever can be varied to adjust the magnification.
- In order to prevent excessive stress on the central portion, the strip is perforated along the centre line by preformation as shown in Figure. The magnification of the instrument is approximately equal to the ratio of rate of change of pointer movement to rate of change in length of the strip



The magnification of the instrument is approximately equal to the ratio of rate of change of pointer movement to rate of change in length of the strip,

i.e.$\frac{dQ}{dL}$ It can be shown that the magnification of the instrument $\frac{d}{d}$ Directly proportional to $\frac{1}{\omega^{2}\,n}$



where,

Q = twist of mid point of strip with respect to the end

L = length of twisted strip measured along its neutral axis

w = width of twisted strip and,

n = number of turns.

It is thus obvious that in order to increase the magnification of the instrument a very thin rectangular strip must be used.

Prepared by: Samiulla Ahmed

ADTW

a door through a window

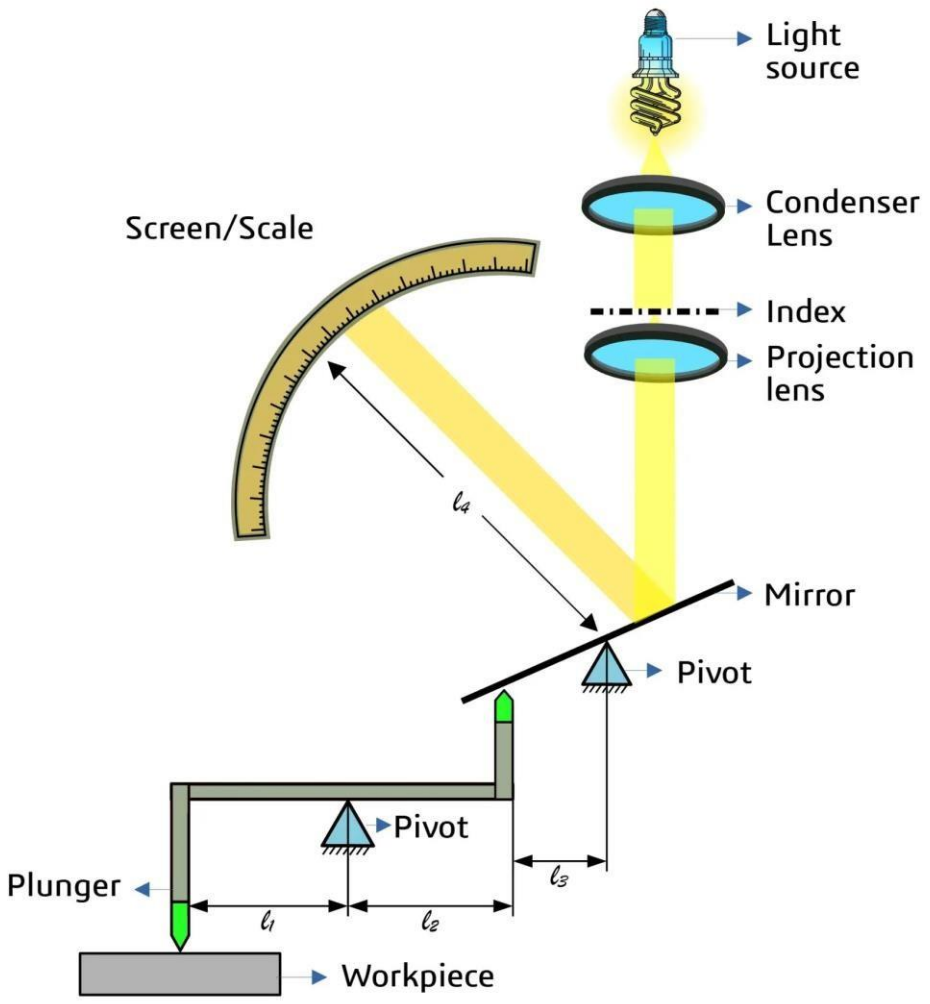
OPTICAL COMPARATOR

Introduction

There are no pure optical comparators but the instruments classed as optical comparators obtain large magnification in these instruments contributes principles though mechanical magnification

- All optical comparators are capable of giving high degree of measuring precision.

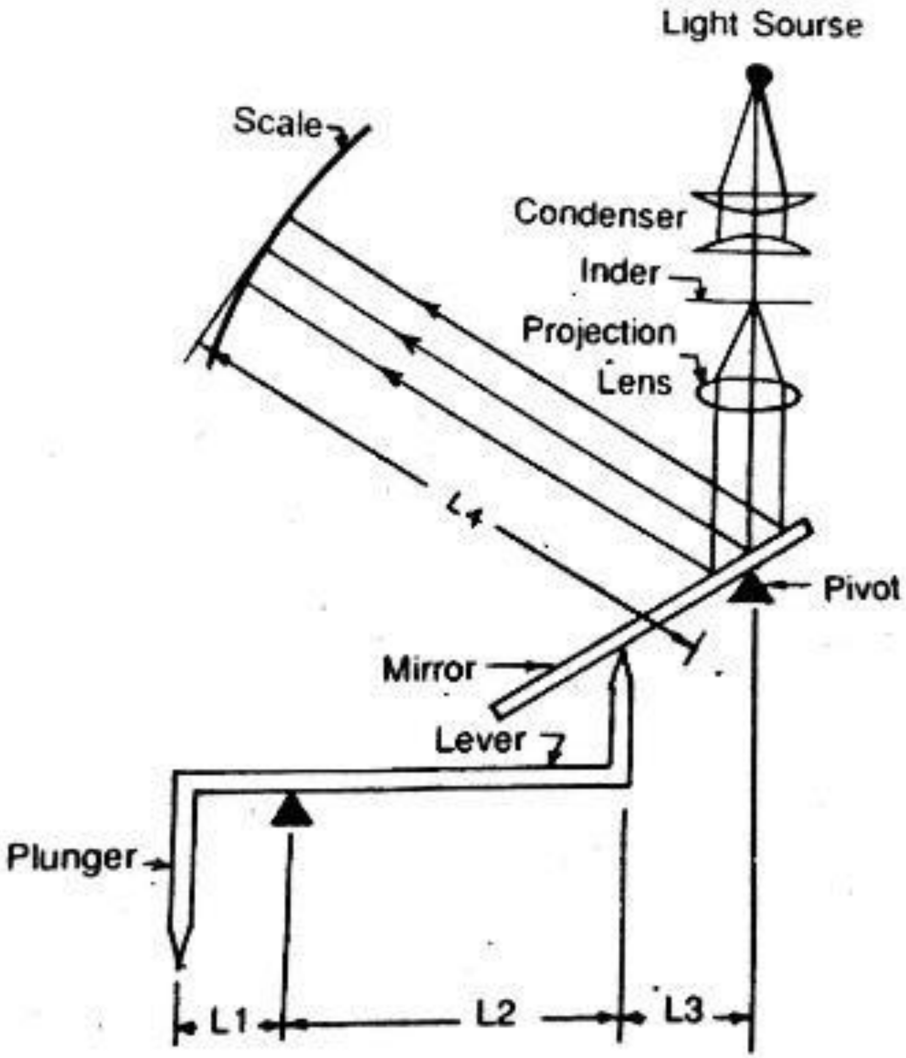
Mechanical Optical Comparator



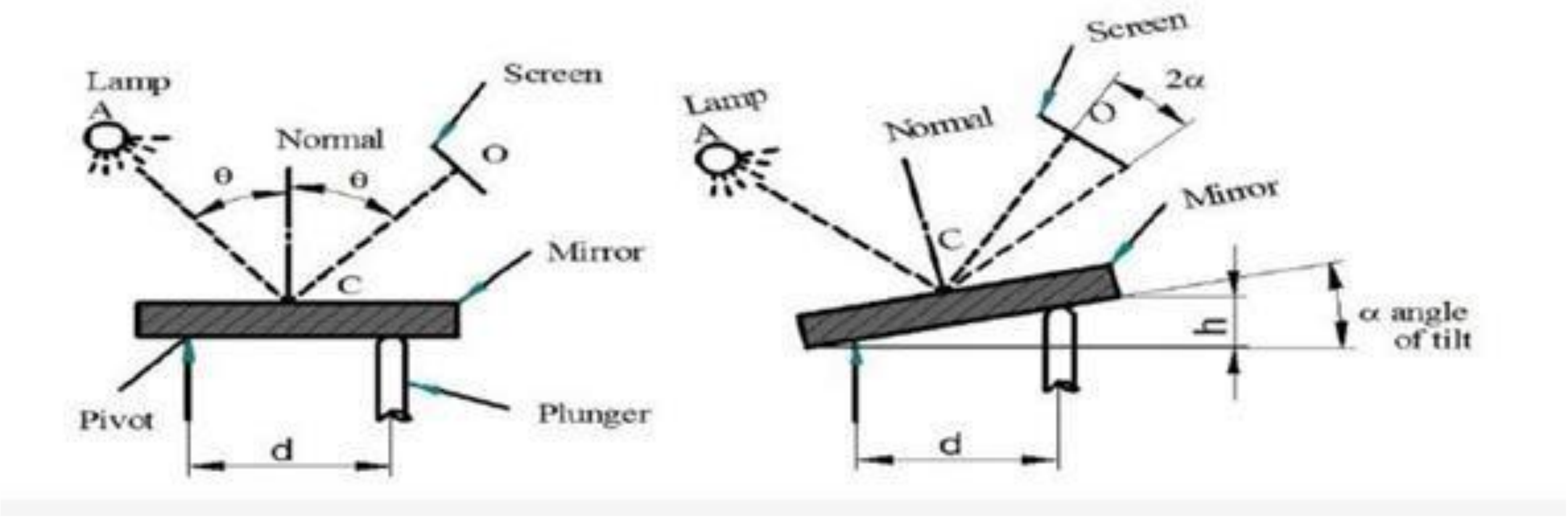
OPTICAL COMPARATOR

Working principle of Optical comparators:

Operating principle of this type, of comparator is based on the **laws of light reflection and refraction**. Magnification system depends on the tilting of a mirror deflects a beam of light, thus providing an optical lever.

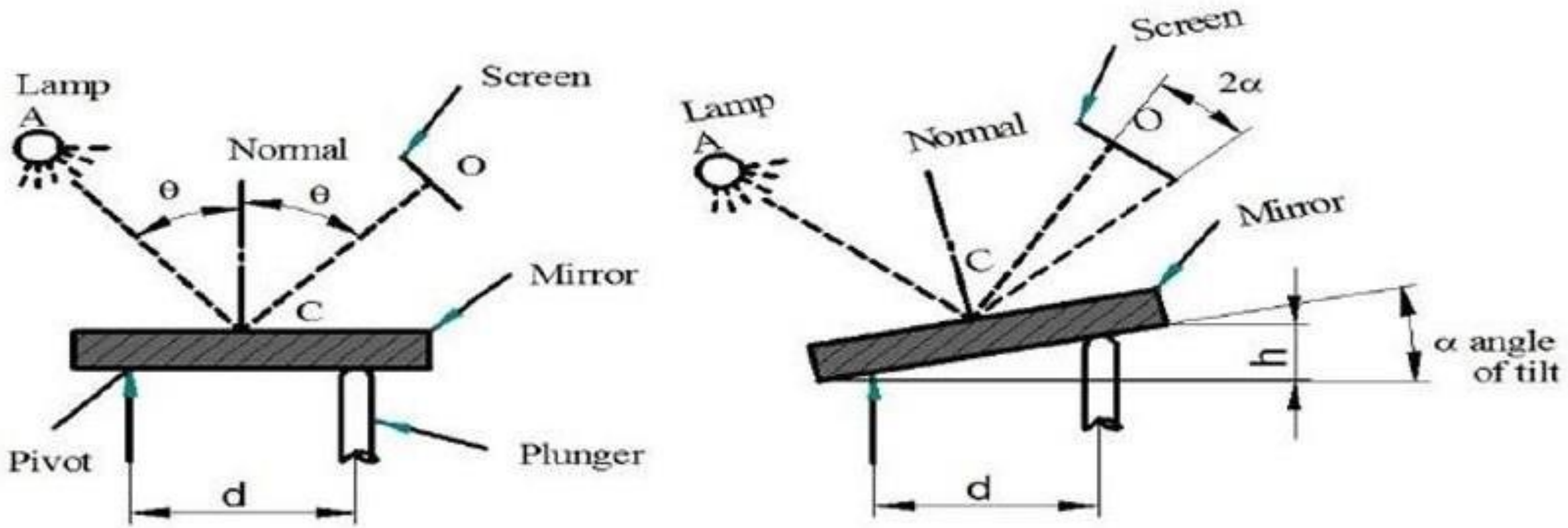


Principle of optical lever



- If a beam of light AC is directed on to a mirror as shown in figure, it will be reflected onto the screen at O as a dot.
- The angle Ө at which the beam strikes the mirror is equal to the angle Ө at which the beam is reflected from mirror.
- When the plunger moves upwards vertically, causing the mirror to tilt by an angle „**α**" as shown in figure.

Principle of optical lever



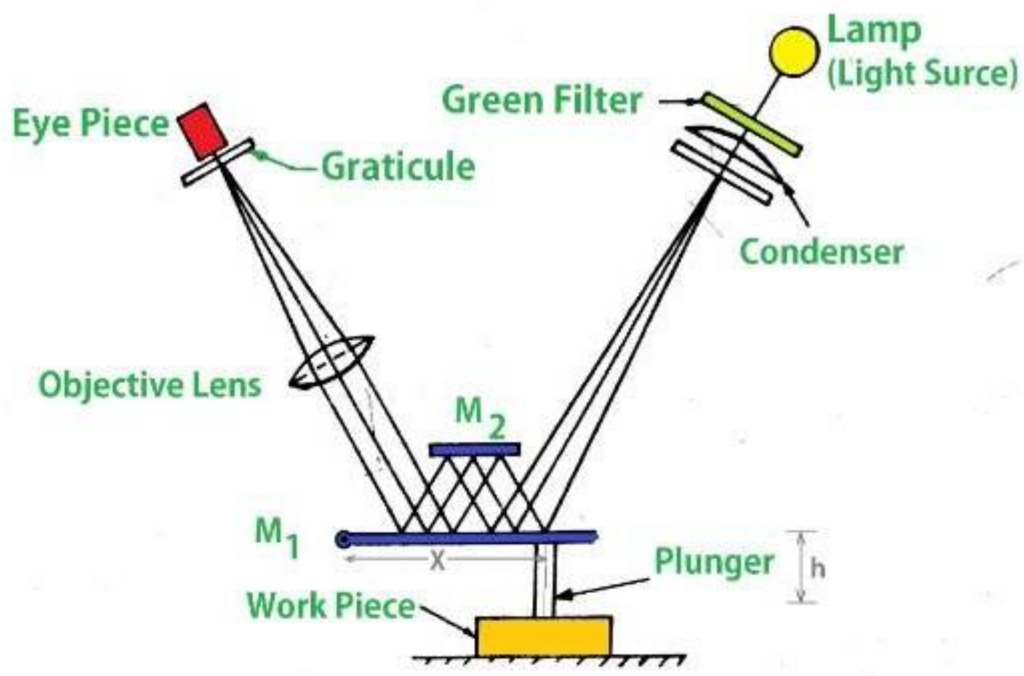
- Then the reflected light beam moves through an angle "**2α**" which is twice the angle of tilt produced by the plunger movement
- The illuminated dot moves to "B" thus a linear movement "h" of the plunger produces a movement of the dot equivalent to the distance OB on the screen.
- It also clear that as the distance (OC) of the screen from tilting mirror increases, greater will be the magnification and is called principle of enlarge image.

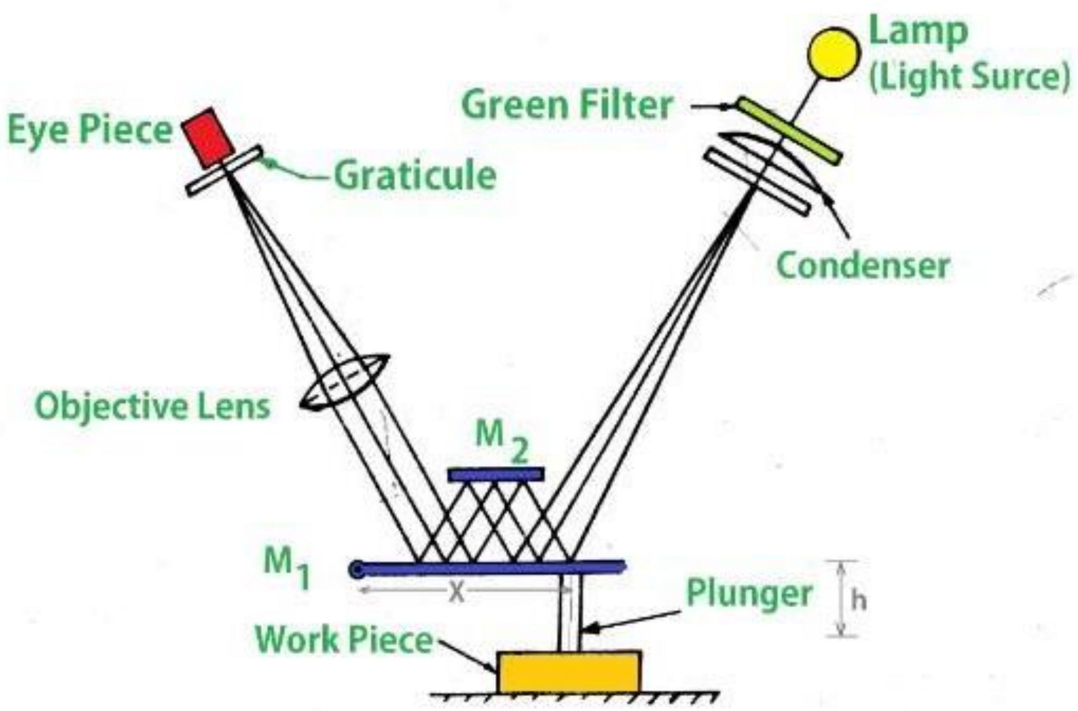

ADTW

Zeiss ultra- Optimeter

- The optical system of this instrument involves double reflection of light and thus gives higher degree of magnification.
- A lamp sends light rays through green filter to filter all rays except green light, which causes less fatigue to eye.
- The green light then passes through a condenser which via an index mark projects it on to a movable mirror M1. It is then reflected to another fixed mirror M2 and back again to first movable mirror.
- The objective lens brings the reflected beam from the movable mirror to a focus at a transparent graticule containing a precise scale which is viewed by eye-piece.

- The projected image of the index line on the graticule can be adjusted by means of a screw in order to set the initial zero reading.
- When correctly adjusted, the image of the index line is seen against that of the graticule scale.





- The end of the contact plunger rests against the other end of the first movable mirror so that any vertical movement of the plunger will tilt the mirror.
- This causes a shift in the position of the reflected index line on the eye piece graticule scale, which in turn measures the displacement of the plunger.

Advantages

- Optical comparators have few moving linkages and hence are not subjected to friction, wear and tear.
- High accuracy of measurement.
- The magnification is usually high.

Disadvantages

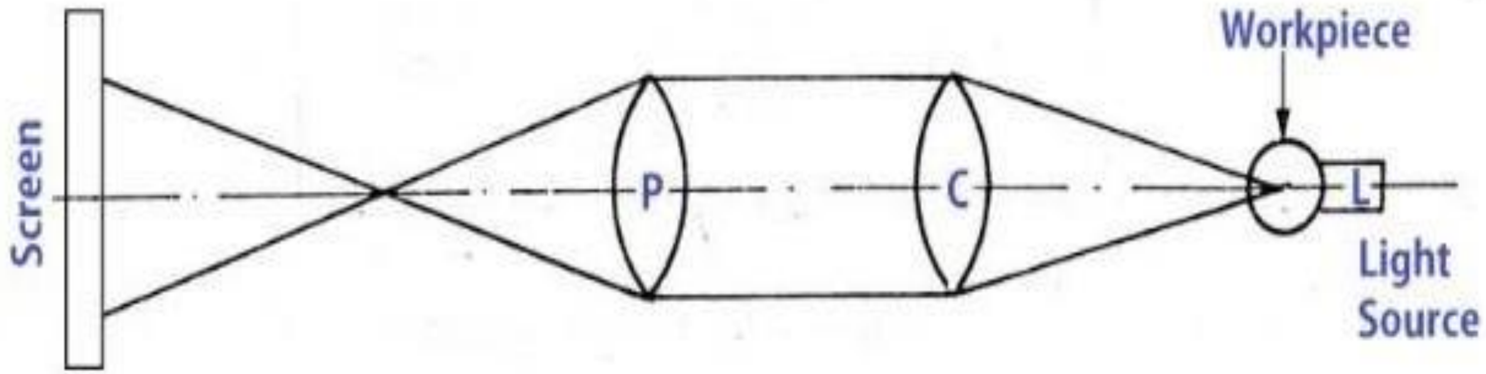
- An electrical supply is necessary to operate these types of comparators.
- The size of these comparators are highly, and costly.
- Since the scale is projected on a screen, it is essential to use these instruments in dark room in order to take the readings easily.

Optical Profile Projector

Optical Profile Projector working principle?

A comparator is a precision instrument used to compare the Dimensions of a given working component with the actual working standard. There are different types of comparators are available.

Optical profile Projector Working principle (Construction)



1.Light source

2.Condenser Lens (C)

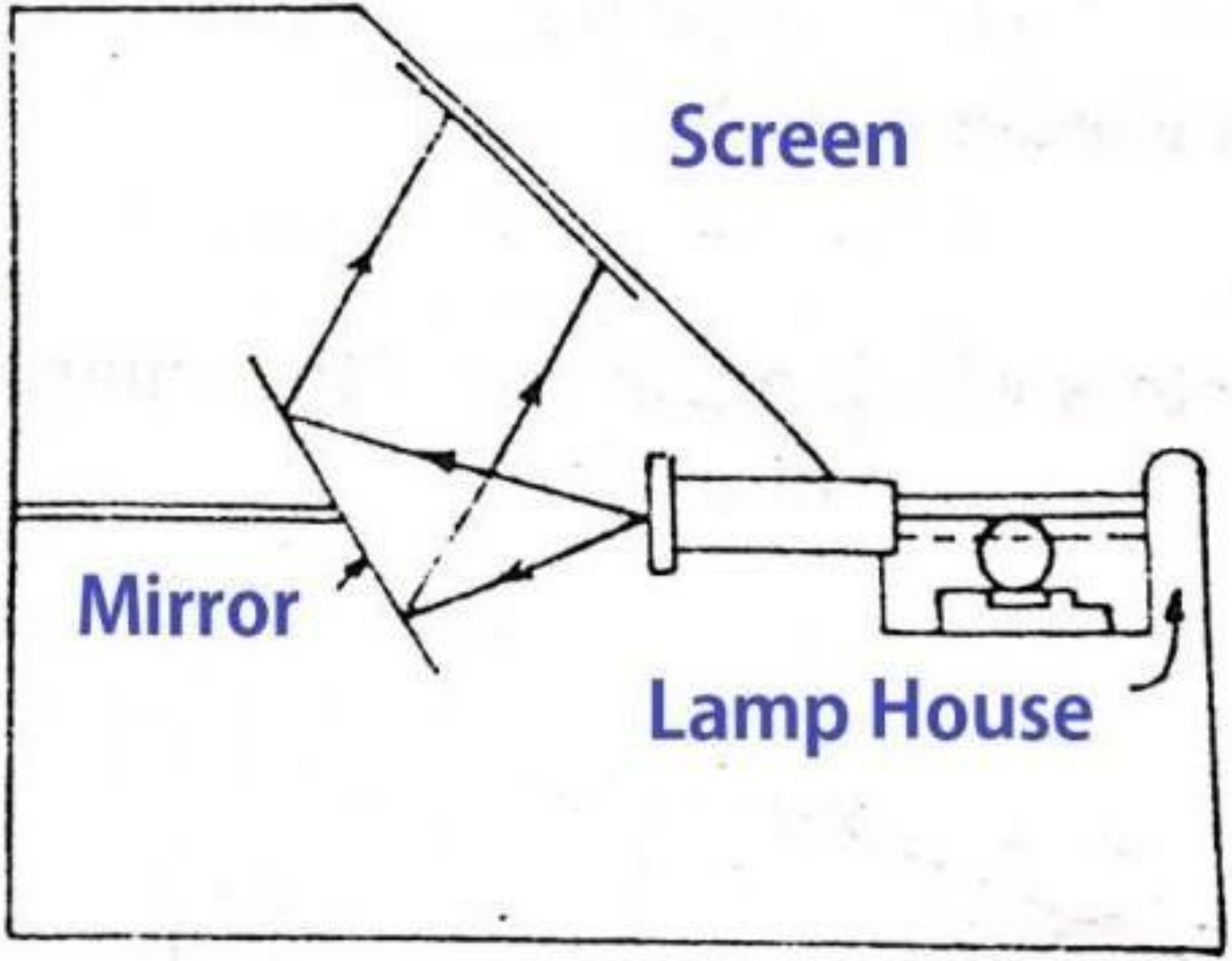
3.Projection Lens (P)

4.Screen

A beam of light from the light source is passed thru the condenser lens(C) and Projection lens(P) and fall on the Screen. the workpiece will be placed in between the light source and condenser lens.

A shadow image of the workpiece will be created. while we placed the workpiece.

The magnified image will be shown on the screen. This magnification is up to 5 to 100.



Screen
Mirror
Lamp House

Optical Profile Projector Applications

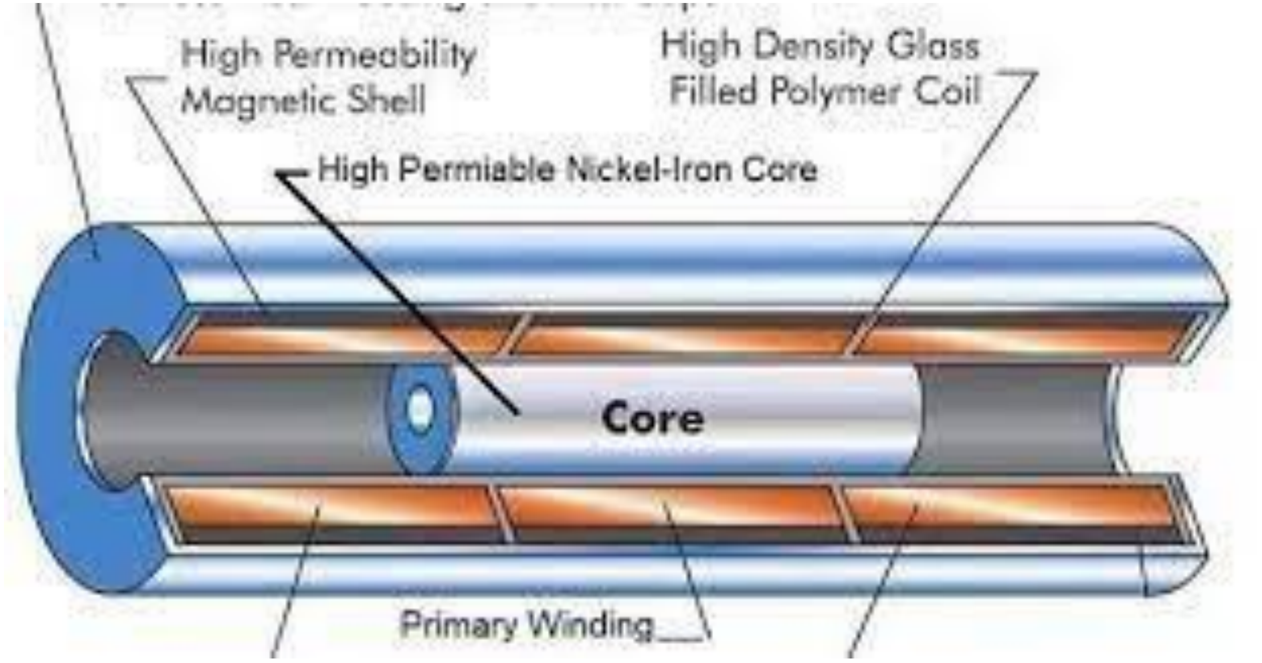
Optical profile projectors have a wide range of applications.

- Used in the automotive industry to inspecting surface deformities.
- In glass Producing industries to inspecting minute flaws in glassware.
- Used to inspect the components with irregular shapes and sizes.

Electrical comparator

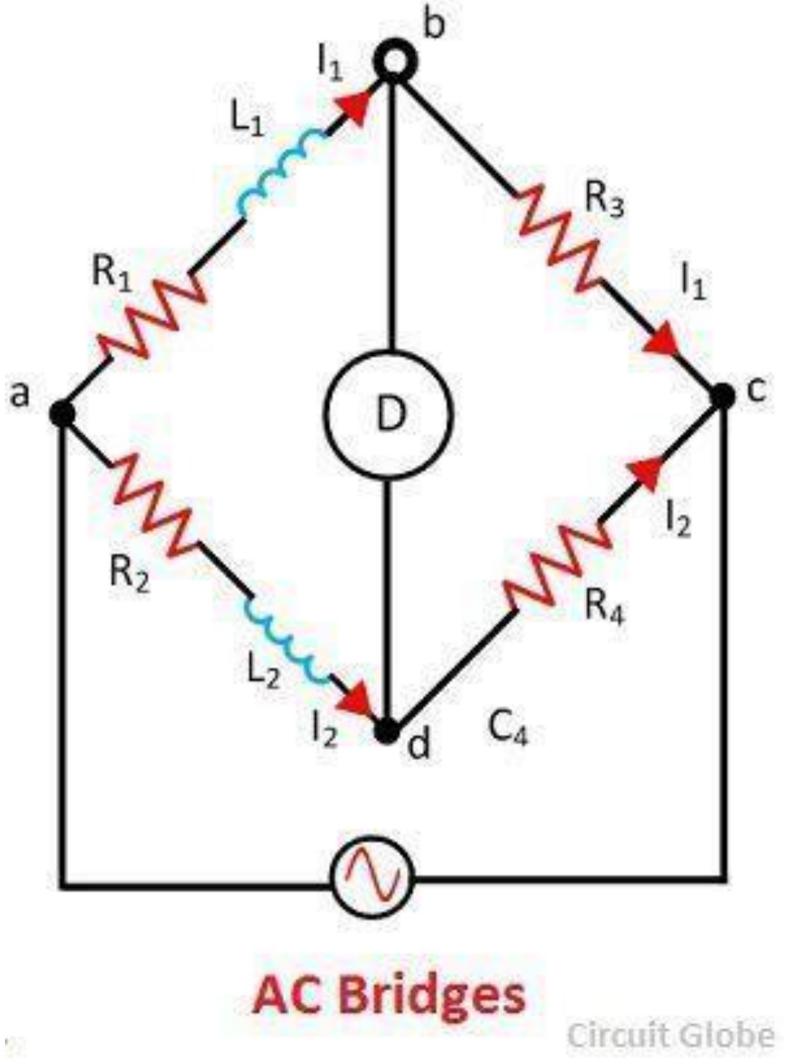
Introduction

- Electrical comparators are also called as electromechanical measuring systems.
- This is because they use an electro-mechanical device that converts a mechanical displacement into an electrical signal.
- **LVDT - Linear Variable Differential Transformer (LVDT)** is the most popular electro mechanical device used to convert mechanical displacement into electrical signal. It is used to measure displacement.



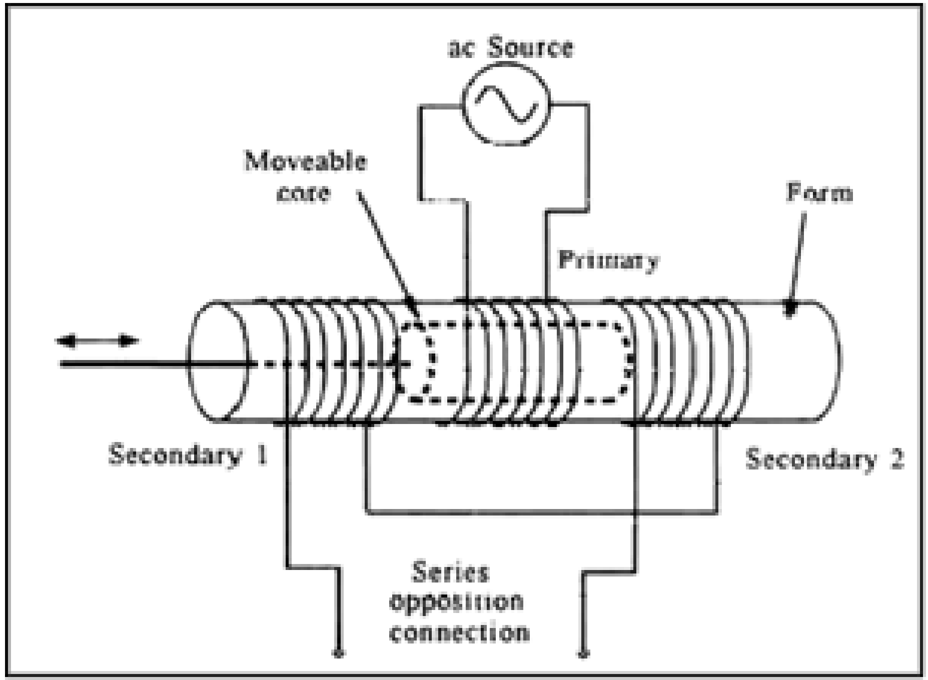
Working principle of Electrical comparators:

These instruments are based on the theory of Wheatstone A.C. Bridge. When the bridge is electrically balanced, no current will flow through the galvanometer connected to the bridge and pointer will not deflect. Any upset in inductances of the arms will produce unbalance and cause deflection of the pointer.



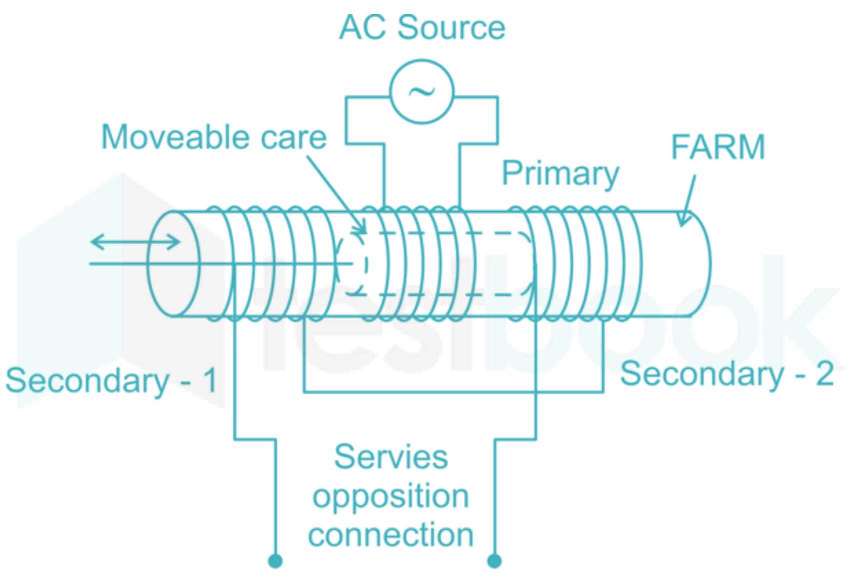
Description

- The LVDT consists of a primary winding and two secondary winding (S1 and S2) which are wounded on a cylindrical former.
- The secondary winding have equal no. of turns
- The secondary windings are placed identically on either side of the primary winding.
- The primary winding is connected to an AC source.
- A movable core is placed inside the cylindrical former.



Operation

- As the primary winding is connected to AC source, it is excited and here a magnetic field is produced. Due to this magnetic field, a voltage is induced in the secondary windings.



- The differential output is E0=Es1- Es2. When the core is in the normal (null) position, the magnetic field linking with both secondary winding S1 and S2 are equal. Hence the emf induced in them is also equal. Therefore, at null position, Es1= Es2, and hence E0=zero.

- When the core is moved to right of the null position, more magnetic field links with winding S2 and less with winding S1. Therefore, Es2 will be larger than Es1. Therefore, the output voltage E0= Es1- Es2 and is in phase with Es2.
- When the core is moved to right of the null position, more magnetic field links with winding S1 and less with winding S2. Therefore, Es1 will be larger than Es2. Therefore, the output voltage E0= Es1- Es2 and is in phase with Es1.
- The output voltage E0 of the LVDT gives a measure of the physical position of the core and its displacement.

Advantage of electrical comparator

- Small number of moving parts.
- Possible to have very high magnification.
- Used for variety of ranges.
- Remote operation can also be done.

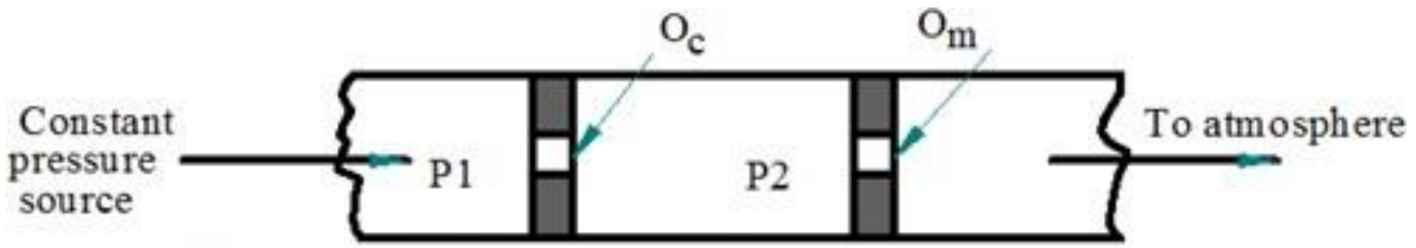
Disadvantage of electrical comparator

- Required an external agency to operate i.e., A.C .power supply.
- Heating coils may cause zero drift.
- More expansive than mechanical comparator.

PNEUMATIC COMPARATORS

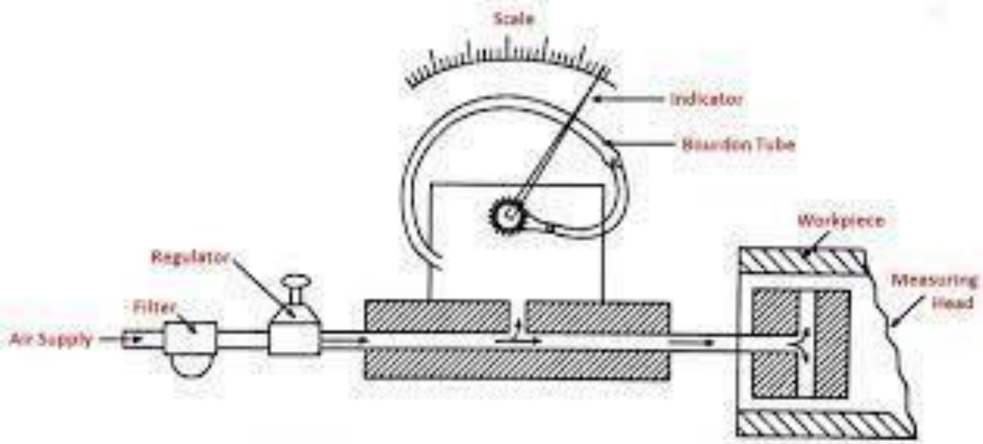
- These instruments utilize the variations in the air pressure or velocity as an amplifying medium.
- A jet or jets of air are applied to the surface being measured and the variations in the back pressure or velocity of air caused due to variations in loused to amplify the output signals.
- Based on the physical phenomena, the pneumatic comparators are classified into two types.
  - –Flow or velocity type
  - –Back pressure type.

Back pressure type



Principle of back pressure type Pneumatic comparator

- The principle of back pressure gauges is that when the orifice Om is blocked, the upstream pressure P1 becomes equal to pressure P2 between the two orifices.

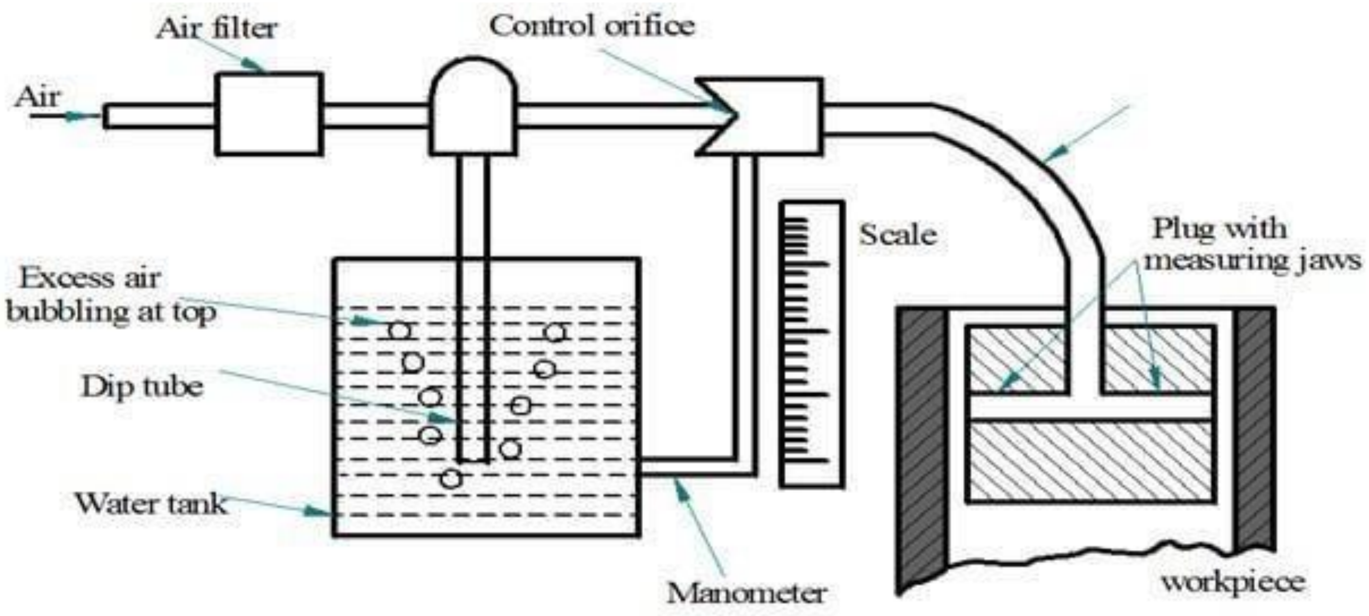


Back Pressure Circuit

- When the orifice opening Om is increased indefinitely, the pressure P2 tends to become zero.
- In the basic back pressure unit shown in fig, a bourdon tube deflects according to back pressure changes built up in the circuit when work piece is placed over the measuring head.
- The deflection is amplified by gear & lever and indicated on a dial.

Solex Pneumatic Comparator

- This instrument was first commercially introduced by Solex Air. Gauges Ltd. It uses a water manometer for the indication of back pressure.



Solex Pneumatic gauge

- It consists of a vertical metal cylinder filled with water up to a certain level and a dip tube immersed into it up to a depth corresponding to the air pressure required.

- A calibrated manometer tube is connected between the cylinder and control orifice as shown in the fig.

- The pressure of the air supplied is higher than the desired pressure, some air will bubble out from the bottom of the dip tube and air moving to the control volume will be at the desired constant pressure.
- The constant pressure air then passes through the control orifice and escapes form the measuring jets.
- When there is no restriction to the escape of air, the level of water in the manometer tube will coincide with that in the cylinder.
- But, if there is a restriction to the escape of air through the jets, a back pressure will be induced in the circuit and level of water in the manometer tube will fall.

- The restriction to the escape of air depends upon the variations in the dimensions to be measured.
- Thus the variations in the dimensions to be measured are converted into corresponding pressure variations, which can be read from the calibrated scale provided with the manometer.

Advantages

- It is possible to have high degree of magnification.
- It is the best method for determining the ovality and taperness of the circular holes.

Disadvantages:

- The scale is generally not uniform.
- The apparatus is not easily portable.


THANK YOU :)