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Unit VI th

1) Mechanical comparator:

a) Dial Indicator.
b) Reed type comparator
c) Sigma comparator
d) Johansson Mikrokator

a) Dial Indicator:

scale

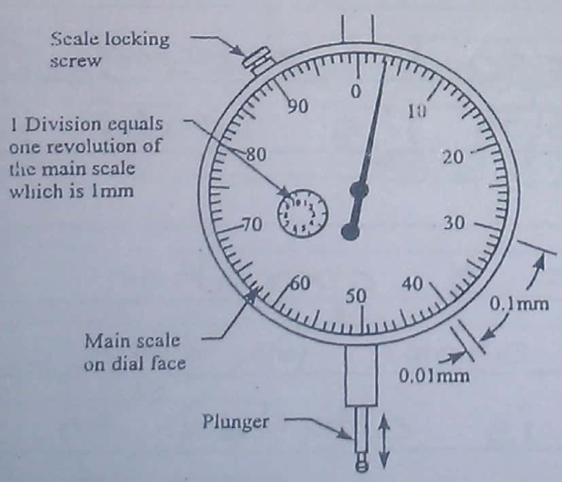

Fig. 4.169. Dial indicator.

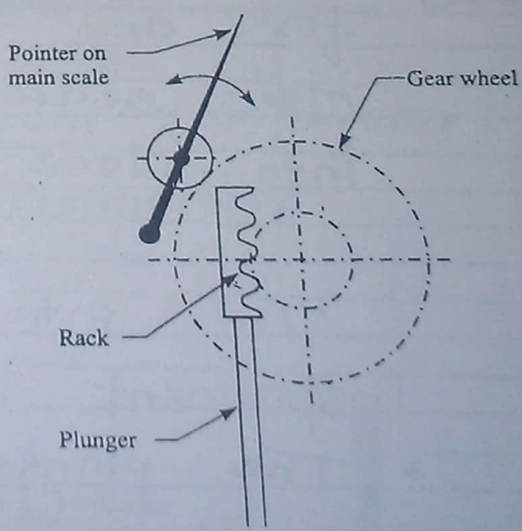

Fig. 4.170. Principle of operation of a dial indicator.

enable - to make able

i) fig.(1). shows the main features of plunger - type dial gauge indicator.

ii) The main scale is graduated into equal divisions corresponding to a 0.01 movement of the plunger.

iii) A second but small dial is set in the main dial face to indicate the number of completed revolutions turne through one revolution being equivalen to 1mm of plunger movement.

iv) To enable the instrument to be zer for any convenient position, the main scale can be rotated & locked into place, using the scale locking s

The principle of operation of the instrument is shown in fig.(2).

- The plunger is attached to a rack.
- Meshing with a gear wheel, the str or linear motion of the rack is converted into an angular or turni motion, the movement being magnif by using a large gear in mesh w a small gear wheel.
- It is the small gear wheel that fitted to the main scale pointer.

fig: (3) shows a dial gauge indicator fitted to a pillar stand; the stand enables the indicator to be locked in any required position.

Fig.(4) shows a workpiece being compared with a known standard, which may be, for example, slip gauges.

- The dial gauge indicator placed so that the plunger is in contact with the reference face, the dial scale can be set to zero and locked.
- Moving the pillar stand (with the dial gauge indicator fitted to it) across to the workpiece, which is positioned on the same flat surface.
- Any difference between the original setting and the face being checked can be read off the main scale.

Imp

b) Reed type Mechanical comparator: Imp
or Mechanical comparator

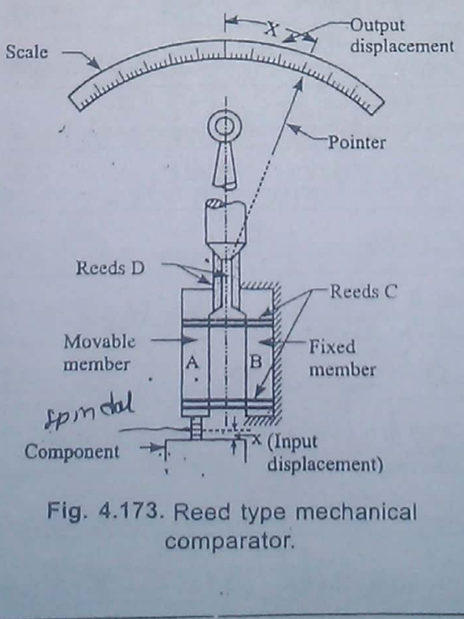

Fig. 4.173. Reed type mechanical comparator.

i) The Reed comparator which is strictly a mechanical comparator because the linkages required for magnification are purely mechanical amplifiers.

ii) A comparator has a sensing probe, a spindle, attached to a movable member 'A'.

iii) member 'A' moves through a diameter x, the input displacement, with respect to member 'B' which is fixed.

iv) Member A is constrained by flexture strips or reeds 'C', to move to 'B'

v) The pointer is attached to reeds 'D'.

vi) A small input displacement 'x', produces a large angular movement 'x'. of the pointer on account of their orientation relative to the motion.

vii) The scale is calibrated by means of gauge blocks and indicates the difference in displacement of the fixed and movable elements.

viii) There is no friction and the hysteresis effect is minimised by using suitable steel for the reeds.

Merits:

i) Easy to handle and operate.

ii) No need of compressed air or electric supply.

iii) cheap in cost & robust in construction

c) sigma comparator:-

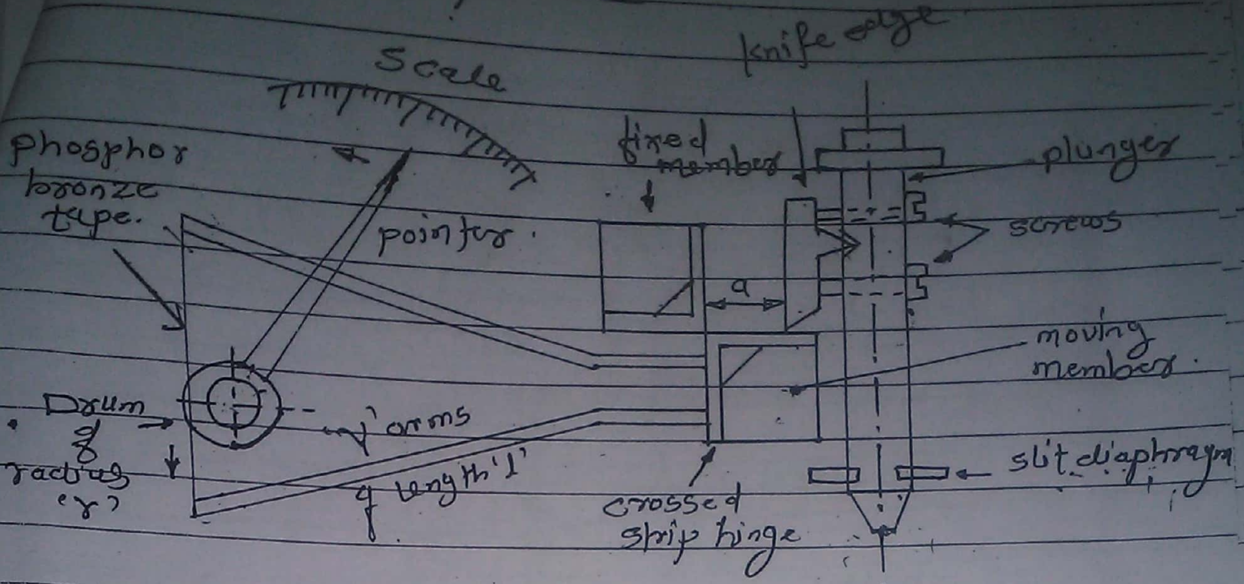

Fig: sigma comparator.

i) The plunger is mounted on a pair of slit diaphragm to give a frictionless linear motion, has mounted upon the face of the moving member. a cross strip hinge.

ii) This hinge consists of the moving component and a fixed component connected by flexible strips alternately at right angles to each other.

iii) An arm (which divides into 'Y' form) is attached to the moving member.

iv) If the length of the arm is 'l' and the distance from the hinge pivot to the knife edge is 'a', then first stage of magnification is l/a.

v) To the extremities of the Y arm is attached a phosphor bronze band or strip which is passed around a drum of radius 'r' attached to the pointer spindle.

If the pointer is of length R, the second stage of magnification is $\frac{R}{r}$.

and total magnification,

$$M = \frac{l}{a} \times \frac{R}{r}$$

where,

$l \rightarrow$ Effective length of arm

$a \rightarrow$ Distance from hinge pivot to knife e

$R \rightarrow$ Length of pointer

$r \rightarrow$ Drum radius

Advantages:→

i) It has got a bold scale and large indicator pointer.

Disadvantages:→

i) Due to motion of the parts, there is wear in the moving parts.

Johansson Mikrokator :→

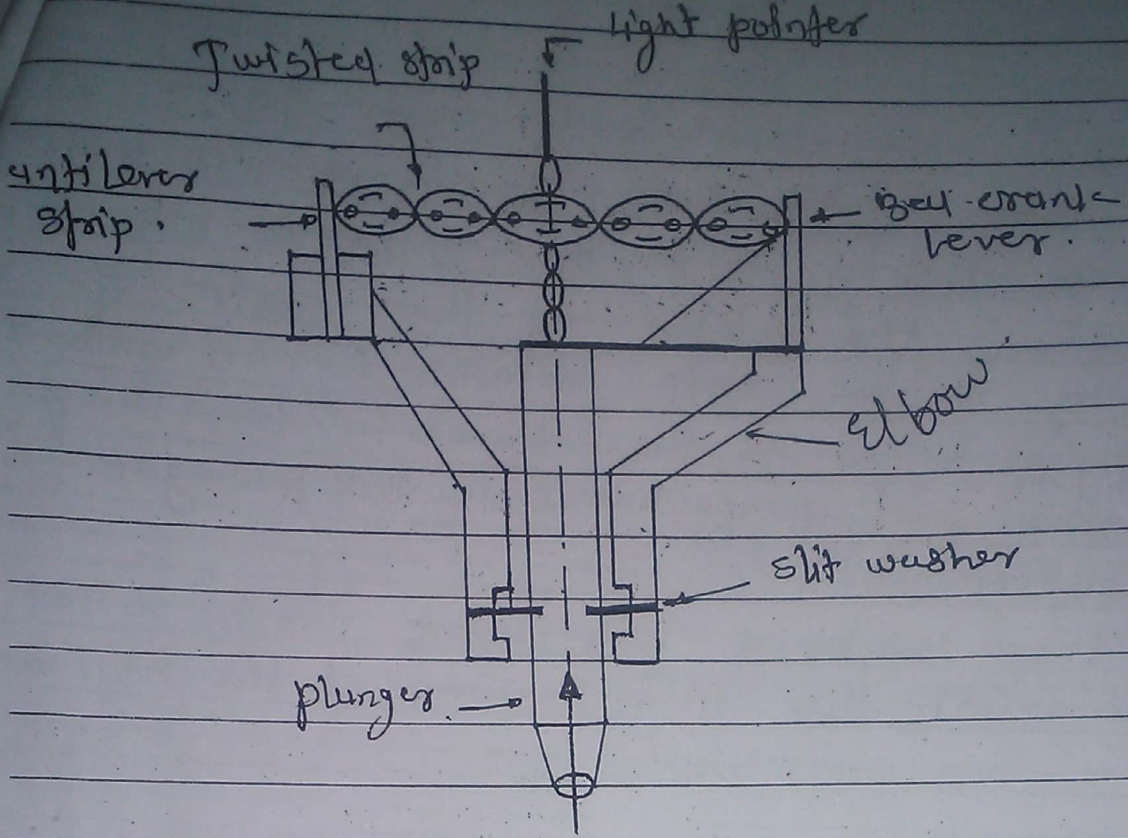

Fig: Johansson Mikrokator

i) A twisted thin metal strip carries at the centre of it's length a very light pointer made of thin glass.

ii) Two halves of the strip from the centre are twisted in opposite directions so that any pull on the strip will cause the centre to rotate.

iii) 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 the measuring plunger.

iv) As the measuring plunger moves either upwards or downwards, the

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elbow acts as a bell crank lever. & causes twisted strip to change it's length thus making it further twist or untwist.

v) Thus the pointer at the centre of the twisted strip rotates by an amount proportional to the change in length of strip and proportional to the plunger movement.

vi) The length of cantilever can be varied to adjust the magnification of the instrume

2) Optical comparator

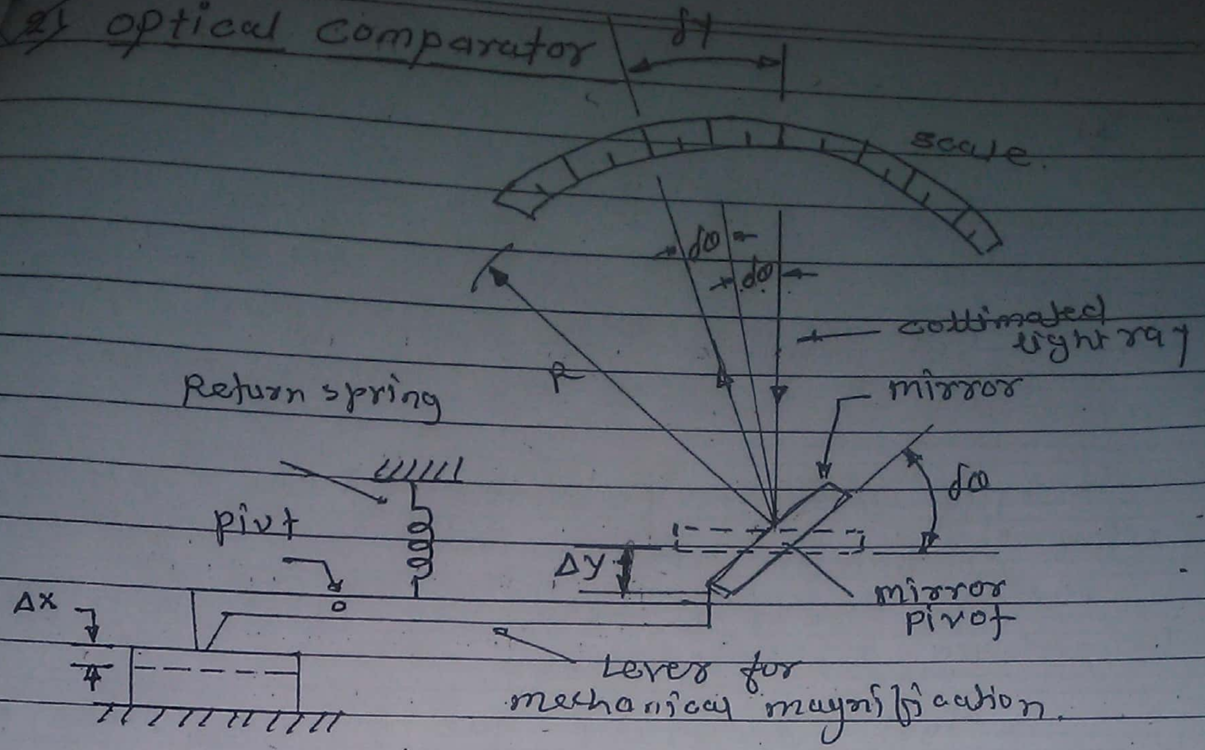


Fig. optical comparator

i) These instruments are usually based on the principle of the reflection of light on a mirror that can be tiled through small angles by the vertical displacement of the measuring plunger around a fixed support. The reflected rays will be seen on graduated scale.

ii) The constructional & operational details of a simple mechanical optical comparator used for measurement of small changes in linear dimensions is shown in figure.

iii) The difference 'Δx' between the two dimensions is amplified by the lever to give a vertical displacement 'Δy' and an angular displacement 'δθ' of a pivot mirror.

iv) The reflected ray is deflected through an angle '2dθ' from the original line and gives a reading of 'dy' on the scale.

v) The magnification takes place through both mechanical and optical methods.

The salient features of an optical comparator are:

- No wear & tear as there are few moving linkages.
- high accuracy due to weightless optical lever, little friction & inertia effects.
- Electrical supply needed to operate the light source.
- For easy reading of the scale, the instrument needs to be operated in a dark room particularly when the scale is projected onto a screen.

advantag.

(1) It have very high magnification
(2) It has small number of ~~Componel~~ moving parts as Compared to mechanical Comparator Hence accuracy is higher

Disadvantage

(1) Electric Supply is necessary
(2) the Component used is large and expensive.

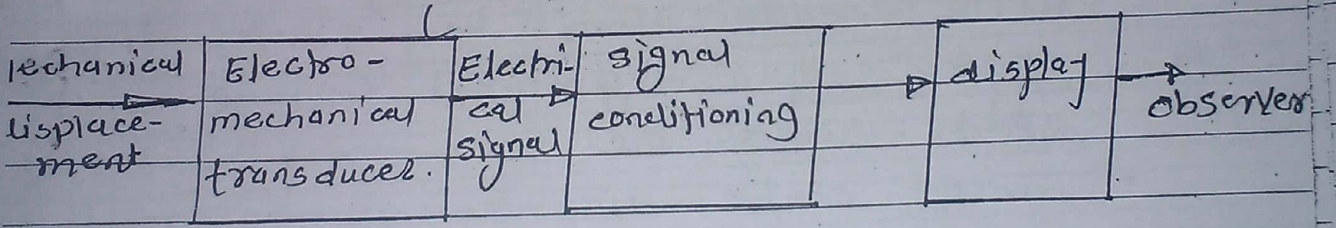
3) Electrical comparator :

- These comparators are also known as "electro - mechanical measuring system" as these employ an electromechanical device which converts a mechanical displacement into in electrical input signal.

Electro - mechanical measuring system :-

Fig. shows block diagram of an elementary electro - mechanical measuring system.

The most popular electro - mechanical device used to convert mechanical displacement into electrical signal is 'Linear variable differential transformer (LVDT).

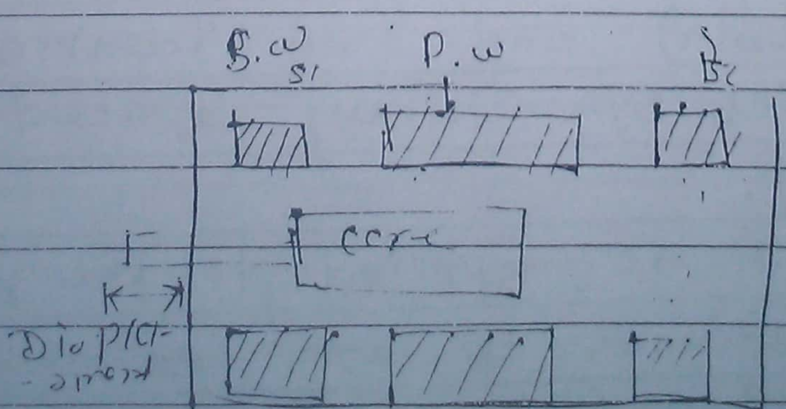


- LVDT is consist of three symmetrically spaced coils wound on a insulated bobbin.
- It works on mutual inductance principle.
- The primary core wound on insulating form (bobbin) and two identical secondaries symmetrically spaced from the primary.
- AC current is applied to the primary and two secondaries are connected in externally in a series operation circuit.
- There is a magnetic core which

moves in the centre of these coils wound on the insulating form and the motion of this core varies the mutual inductance of each secondary to primary which determines the voltage induced from the primary to each secondary.

- If the core is centred in the middle of the two secondary windings, then voltage induced in each secondary winding will identical and 180° out of phase, and the net output will be zero.
- If the core is moved off middle position then the mutual inductance of the primary with secondary will be greater than the other, and a differential voltage will appear across the secondaries in series.
- For off centre displacements within linear range of operation, the output is essentially a linear function of core displacement.

:-o-:



Pneumatic comparator :

The measurement is done with the help of compressed air. Either air flow or air pressure variation is used to measure deviation from standard or reference dimension.

1) The flow or column type comparator :→

Fig: 1) shows a pneumatic comparator based on measurement of the change in the rate of flow.

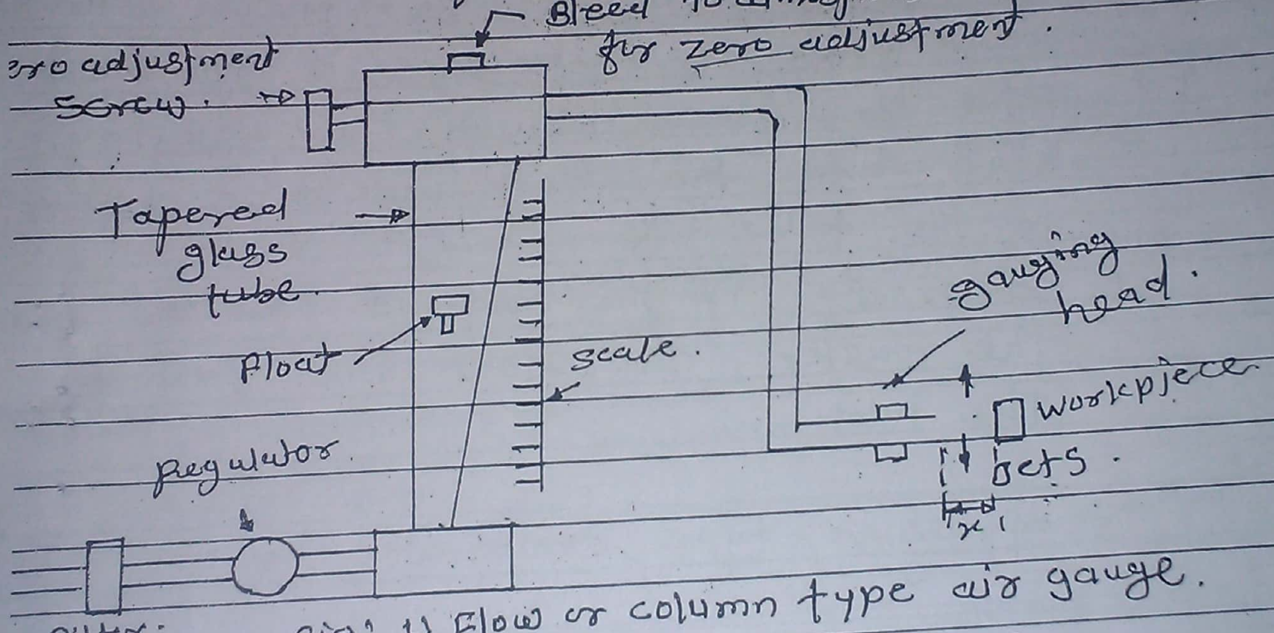


Fig: 1) Flow or column type air gauge.

- The air has passed through a filter and a regulator, it is supplied to the gauge at about 70 kpa.
- The air flows through a uniformly tapered glass tube in which a float is suspended by this air flow.
- The float is provided with vanes to rotate and give it's stability.
- The top of the tube is connected to the gauging head by a plastic tube.

- The air flowing through the gauge exha through the passages in the gauging head into the clearance betn the head and the workpiece.
- The rate of flow is proportional to the clearance indicated by the position of float in the column.
- If the hole in the workpiece is larger than the hole size of the master, more air flow through the gauging head and the float will rise higher in the tube.
- Conversely, if the hole is smaller than the master, the float will fall in the tube.

2) Pressure type comparator :-

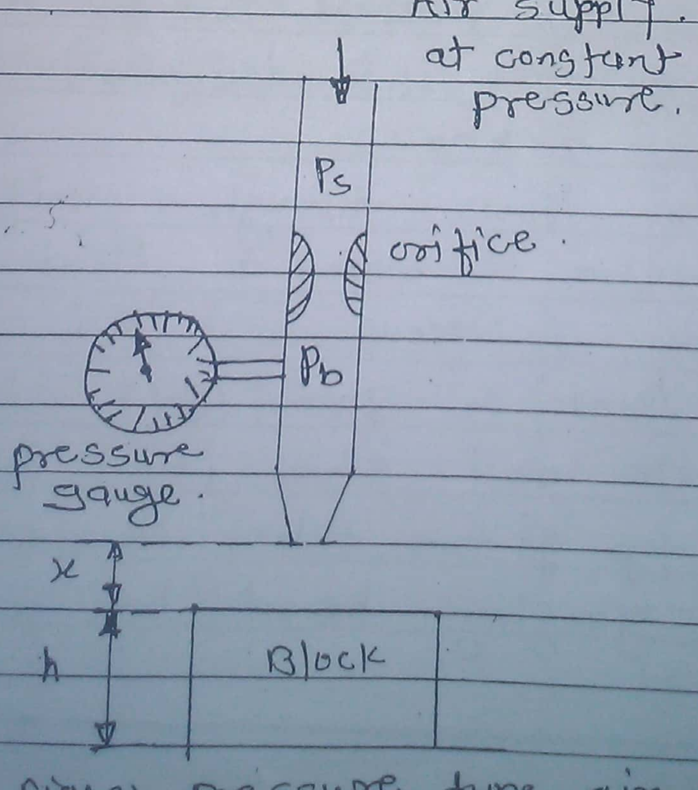


Fig:2) pressure type air gauge

IMP

Autocollimator

- An autocollimator is an instrument designed to measure small angular displacement and may be used in conjuction with a plane mirror or other reflecting surfaces. An autocollimator is essentially an infinity telescope & a collimator combined into one instrument.

Principle
- An autocollimator is based on the principle that a collimating lens can project and receive a parallel beam of light and the reflected beam of light will change it's direction by changing the angle of the surface reflecting the light.
- The autocollimator's principle is shown in figure.

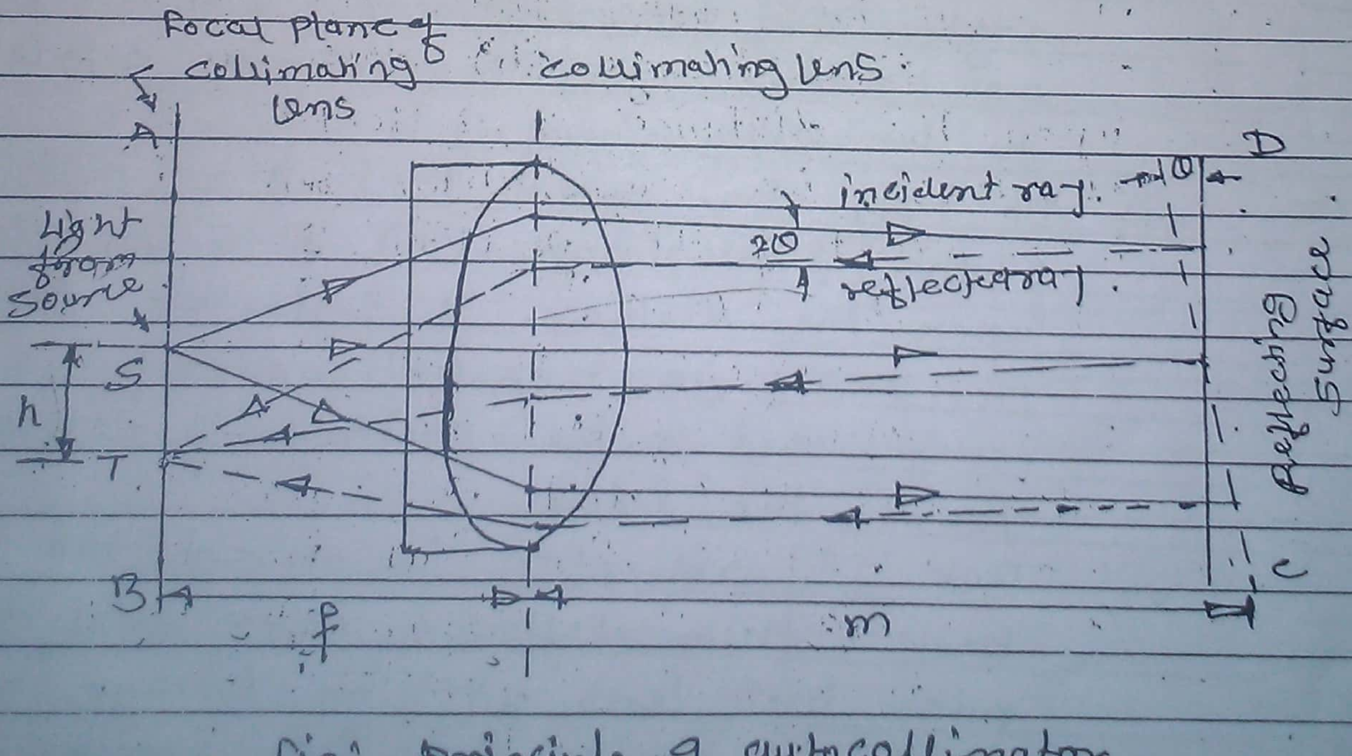


fig: principle of autocollimator.

i) Suppose a ray of light is emitted from source 'S' at the middle of the focal plane of collimating lens.

ii) The lens will convert this into a parallel beam which is then reflected from some working surface, such as 'CD'.

iii) If 'CD' is inclined at an angle 'θ', the reflected beam will change it's path at twice the angle θ i.e. 2θ.

iv) The reflected beam re-enters the collimating lens to be focussed at some new point in the focal plane such as 'T'.

v) Distance 'h' is proportional to the angle and measurement of 'h' in plane AB enables values of small angles to be determined.

vi) It may be noted that the position of the final image (h) does not depend upon the distance of reflector from the lens, i.e. separation 'm' is independent of the position of reflector from the lens.

vii) But if reflector is moved too much back then reflected rays will complet miss the lens and no image will be formed. Thus, for full ~~image~~ rang of readings of instrument to be us the maximum remoteness of the reflector is limited.

$$h = 2 \times f \times \theta$$

where,

f → focal length of the lens.
θ → angle of tilt of mirror (Reflecting surface).

So by measuring this distance (h), inclination of reflecting surface can be estimated.

Uses :→

i) Examination of plane surface.
ii) checking squareness of two surfaces.
iii) checking alignment or parallelism.

2).

* Toolmaker's Microscope *

The toolmaker's microscope is an optical measuring machine equipped for external & internal length measurements as well as measurements on screw threads, profiles, curvature and angles.

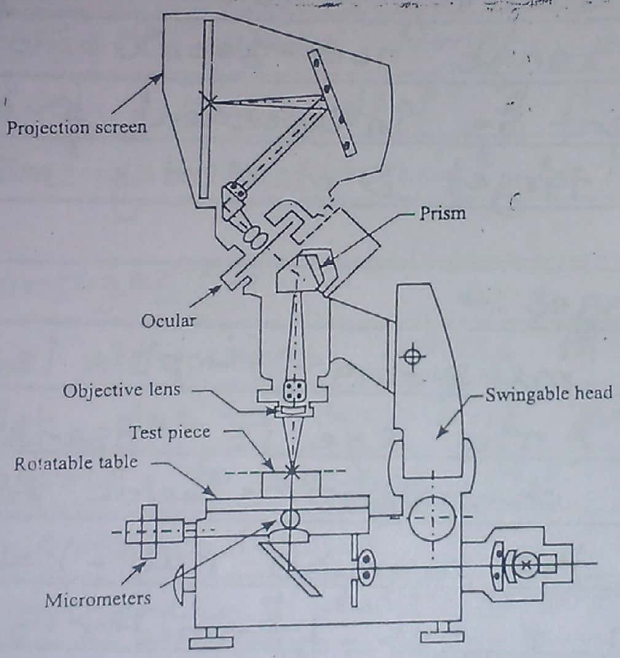


Fig. 4.193. Toolmaker's microscope.

optical → of eye on sight दृष्टि सं
lence → दुर्बिणीचा काँच
prism → block of glass that separates sunlight into colours.
Ocular → of the eye, दृष्टीचा

The main parts of the toolmaker's microscope are :

1) Rotatable table
2) Measuring stage
3) swingable head
4) ocular
5) Projection screen.
6) Micrometers.
7) objective lens
8) prism.

Construction :→

i) The toolmaker's microscope consists of a rigid stand on which a swingable head is mounted.

ii) The measuring stage moves on ball guideway by actuating two measuring micrometers arranged perpendicular to each other in the length and the cross-sections.

iii) The measuring range of each micrometer is 25 mm and the measuring capacity can be increased using slip gauges.

iv) A rotatable table is provided over the stage, on which the workpiece can be fixed either directly or between centres.

v) This table can be rotated through 360°.

Working :→

i) The component being measured is illuminated by the through light method.

ii) A parallel beam of light illuminates the lower side of workpiece which is then received by the objective lens in it's way to a prism that deflects the light rays in the direction of the measuring ocular and the projection screen.

iii) Incident illumination can also be provided by an extra attachment.

iv) Exchangeable objective lens having magnificati 1X, 1.5X, 3X & 5X are available so that a total magnification of 10X, 15X, 30X & 50X can be achieved with an ocular of 10X.

v) The direction of illumination can be tilted with respect to the workpiece by tilting the measuring head and the whole optical system

vi) This inclined illumination is necessary in some cases as in screw thread measurement

- - - -

* Profile projector (optical)

* Basic optical system of projector :

The basic optical arrangement of all projectors is shown in fig below.

The four essential elements in a projection system are:

1) source of light.
2) collimating or condensing lens.
3) projection lens.
4) screen.

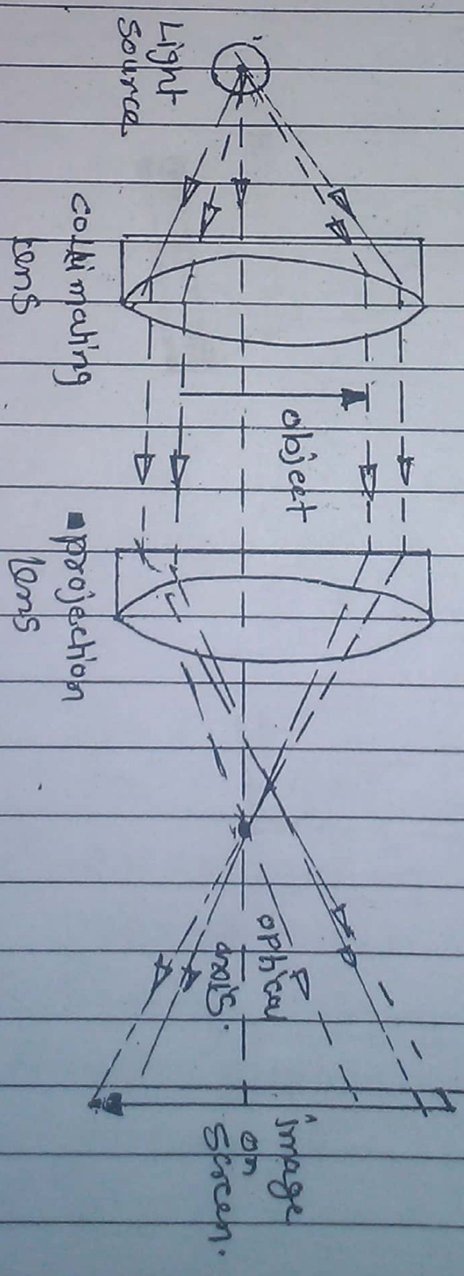


Fig: Basic optical system of projector

- The illumination required for practically all engineering projectors is a parallel beam, and therefore the source of light must be as nearly as possible a point source, placed at the principle focus of the collimating lens.
- The name 'condenser' is often used for this lens.
- "collimator" is a much more accurate term since it implies that the beam from it is rendered parallel.
- The projection lens is always a combination of lenses and forms on the screen a real image of an object placed betn it & the collimator.
- The screen may be transluscent, in which case the image is viewed from the opposite side of the screen.
- A projector may be arranged for the projection of the image in a direct line of the screen.

Profile projector :-

Profile projector is an optical device which is used to check profile of component having special formed surfaces as gears screws and those objects having regular or irregular profile.

The main objective lens is interchangeable, giving a magnification range X10, X25, X30, X60, X100 and X200. The graticule also is interchangeable to cater for linear, angular, radial and thread form inspection. The tool makers' microscope, although capable of inspecting any component shape that can be accommodated by optical projectors, is best suited to relatively small, intricate components and tools.

3.3 Optical Projectors

The optical projector is a versatile and indispensable instrument in the metrology laboratory. The projector may be used to check the components which are otherwise difficult to do so due to typical of their size, material and dimensional characteristics. The instrument displays the magnified images of the objects located on the working platform - on an appropriate viewing screen. The magnified image serves as an aid to more precise determination of dimension, form, etc.

The optical system of a projector consists of

1. a projector - light source and condenser
2. suitable work holding table either fixed or movable
3. projection optics - mirrors and lenses
4. screen - for viewing the image and checking is made possible
5. measuring devices - precise mechanical system of measuring aids.

The following measurement techniques are employed on optical projectors

1. measurement by comparison
2. measurement by movement - table travel and measuring facilities must be available.
3. measurement by translation - special tracer accessories are required.

3.3.1 Nikon optical profile projector

Optical measuring instruments offer a number of advantages over mechanical instruments and provide suitable alternative. These are preferred when contact measurement cannot be used, as in the case of the fragile components or when the shape is highly complex or object is too small. In contrast to the optical comparator which employs an optical system to magnify the movement of a measuring probe, optical measuring instruments use a system of lenses to give a magnified image of the object. The use of light as a means of measurement can often involve a level of accuracy which cannot be achieved by mechanical instruments. A beam of light is unaffected by distortion and temperature variation although it is dependent on the quality of the optical system.

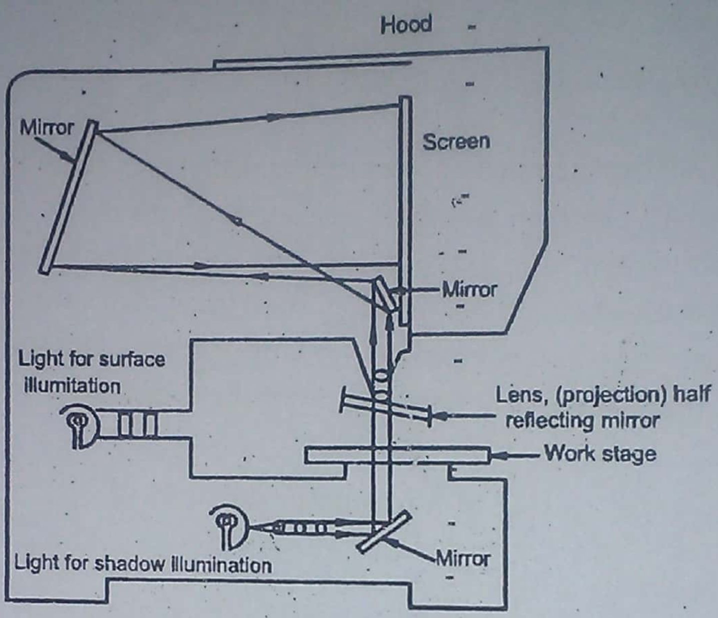


Fig. 3.3 Profile projector (Optical system)

Figure 3.3 shows Nikon profile projector which has swiveling turret above the stage for mounting the projection lenses. This enables different magnifications to be selected fairly rapidly. The illumination can be switched from shadow to surface by a selector on the front of the instrument. The hand wheel on the right hand side will raise or lower the stage and hence position a component placed on it at the focal point of the lens.

A sliding hood can be positioned to prevent extraneous light shining on the screen. From the above figure it can be seen that, when used for shadow illumination, collimated light is transmitted up through the translucent stage back lighting any object placed on it. Alternatively, when surface illumination is selected, the light strikes a half reflecting mirror placed below the projection lens, which reflects it down on to the object on the stage.

Whichever means of illumination is used, the image is projected by the lens via the two mirrors in the upper part of the instrument, on the screen.

All objects are not suitable for placing directly on the stage. Awkwardly shaped objects can be mounted between the centers. The stage can be moved on its longitudinal and transverse direction and the movement is controlled by micrometers which have a vernier resolution down to 0.001mm.

designed on one of the two basic principles : One involves the *use of a spirit level* and the other makes use of the *plumb-bob (or pendulum) principle* and works from the vertical.

Clinometers are *used for checking angular faces, and relief angles on large cutting tools and milling cutter inserts*. These can also be *used for setting inclined table on jig boring machines and angular work on grinding machines etc.*

The different types of clinometers available are :

1. Vernier clinometer
2. Micrometer clinometer
3. Dial clinometer
4. Pendulum clinometer
5. Optical clinometer.

The most commonly used clinometer is of Hilger and Watt type. The circular glass scale is totally enclosed and is divided from 0° to 360° at 10' intervals. Sub-division of 10' is possible by the use of an optical micrometer. A coarse scale figured every 10 degrees is provided outside the body for coarse work and approximate angular reading. In some instruments worm and quadrant arrangement is provided so that reading upto 1' is possible.

In some clinometers, there is no bubble but a graduated circle is supported on accurate ball bearings and it is so designed that when released, it always takes up the position relative to the true vertical. The reading is taken against the circle to an accuracy of one second with the aid of vernier.

4.4.1.2.8. Plain index centre

Fundamentally index centres were meant for use on milling machines but they are now being used for inspection work also. This is specially suited to those problems which involve the measurement of a large number of angular dimensions about a common centre. The work is set between the centres and correct angular dimensions are set directly from the indexing plate.

To obtain wide range of angles the following types of indexing methods may be employed :

1. Single indexing
2. Differential indexing
3. Compound indexing.

4.4.1.2.9. Optical instruments for angular measurement

Autocollimator. An autocollimator is an instrument designed to measure *small angular deflections* and may be used in conjuction with a plane mirror or other reflecting surface. An *autocollimator is essentially an infinity telescope and a collimator combined into one instrument.*

An autocollimator is based on the *principle that a collimating lens can project and receive a parallel beam of light and that the reflected beam of light will change its direction by changing the angle of the surface reflecting the light.*

The Autocollimator's principle is shown in Fig. 4.88. It shows the collimator lens that projects a parallel beam of light along the optical axis of the system when the light source (electric bulb) is placed at the focus of the collimator lens. A reflector, which can be a slip guage block, an optical flat or a mirror is attached to the surface under rest. If this reflection is accurately normal to the optical axis, the effected beam will return along its original incident path back to the lens and will be collected at a point '*p*' exactly at the length of the lens where cross-wires are placed. Therefore the image of the cross wires formed by the reflected light

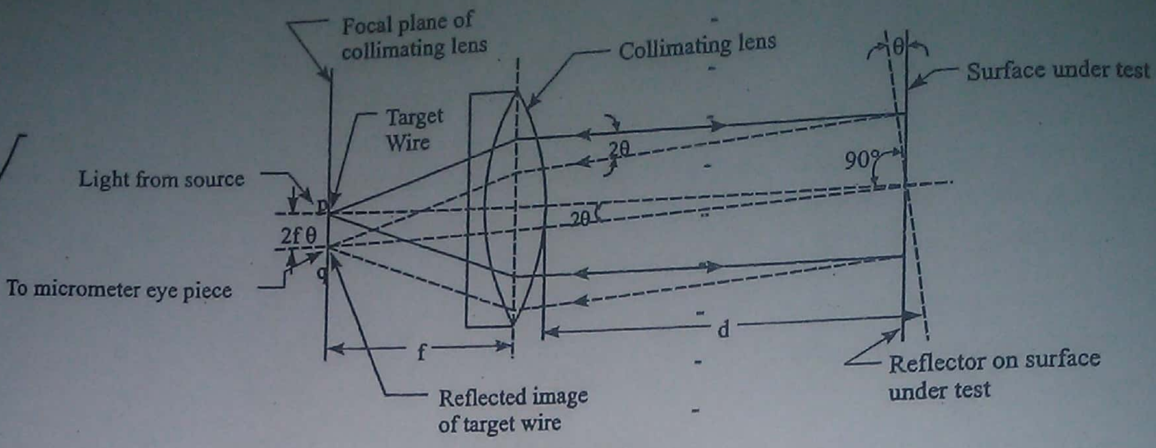


Fig. 4.88. Principle of autocollimator.

beam will, in this case coincide with the cross-wires at point 'p'. If the reflection is slightly tilted at an angle θ, the reflected beam will change its path at twice the angle θ. The reflected beam will, therefore, form an image 'q' at the cross-wires at distance 'pq', the value of which is a measure of the angular deflection θ, where $pq = 2f \cdot \theta$.

- It may be noted that the position of the final image does not depend upon the distance of reflector from the lens, *i.e.*, separation 'd' is independent of the position of reflector from the lens. But if reflector is moved too much back then reflected rays will completely miss the lens and no image will be formed. Thus, for full range of readings of instrument to be used, the maximum remoteness of the reflector is limited.

For high sensitivity, *i.e.*, for large value of 'd' for small angular deviation θ, a long focal length is required.

Hilger angle dekkor :

Fig. 4.89 shows a typical auto-collimator–the Hilger Angle Dekkor, the description of which is given below:

- It consists of a *tubular body* containing the *collimating lens* at one end and viewing *eye piece* at the other end.
- At the focal plane of the collimating lens, there is a scale instead of cross-wires which is illuminated by means of an electric lamp mounted by the side.
- The *eye piece* is provided with a *fixed scale* similar to and at right angles to the illuminated one.

Both scales are divided from 0 to 40 and each division represents 1' of arc.

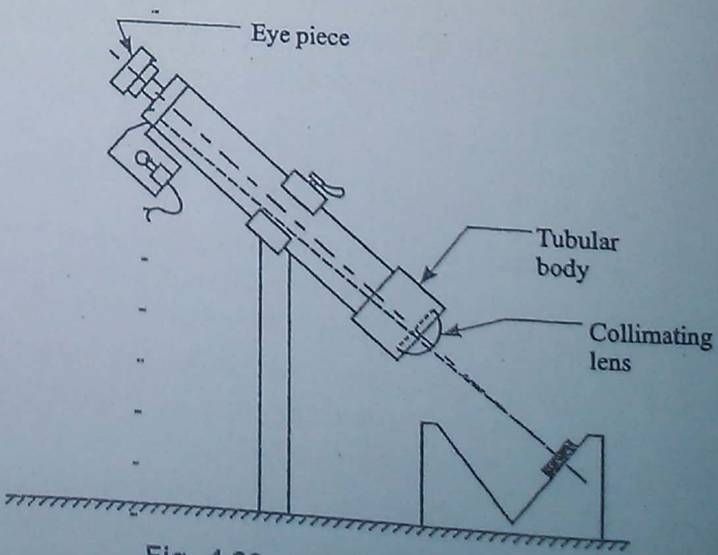


Fig. 4.89. Hilger angle dekkor.

Photo-electric micro-optic auto-collimator

Photo-electric setting makes measuring and checking by auto-collimator far simpler and faster. Micrometer adjustment is provided for setting but coincidence of setting graticule and target image is *detected photoelectrically*, and shown on a meter as a null reading. This provides a high degree of sensitivity and repeatability, also reducing eye fatigue to a minimum. The eyepiece is normally only used to assist in initial setting up.

The photo-electric auto-collimator is particularly *suitable for calibrating polygons, for checking angular indexing and for checking small linear displacements.*

Application of auto-collimator. The auto-collimator can be used for measurement of angles of *surfaces which are of reflective nature.* Thus newly machined and polished surfaces will reflect. In case the *surface does not reflect then a parallel slip gauge is wrung to the surface.* Fig. 4.91 shows the use of auto-collimator to *compare* the angle of a precision angle plate with that between two faces of an eight-edged reference plane :

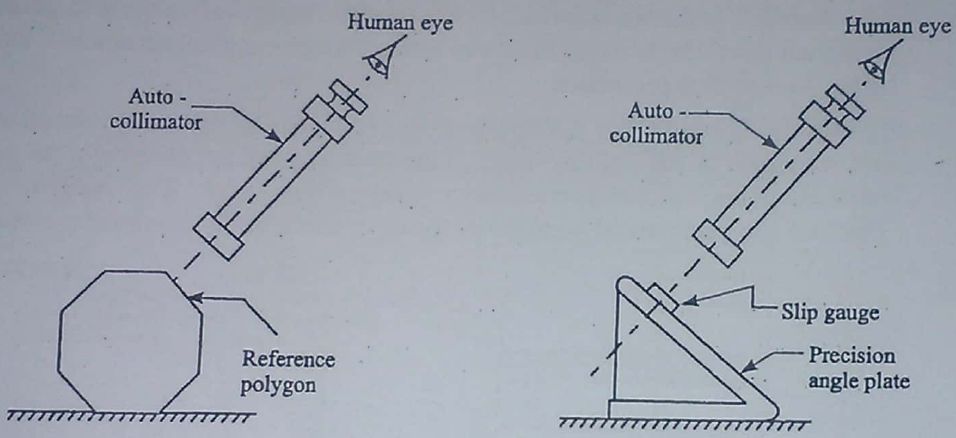


Fig. 4.91. Use of auto-collimator.

- The instrument is firmly fixed in position relative to the surface plate and the reading is taken with polygon in position.
- The polygon is then removed and replaced by an angle plate plus the slip gauges if necessary and a new reading is taken.
- The difference between the two sets of readings must be added or subtracted from the known angle between the particular pair of polygon faces, to give the angle of face plate.

4.4.2. Taper Measurement

4.4.2.1 Gauges for tapers

- A taper is tested by using taper plug and ring gauges. The important thing in testing a tapered job is to check the diameter at bigger end and the change of diameter per unit length. For testing the correctness of a taper, three light lines are drawn with persian blue about equidistant along the length on the (male portion) plug gauge or spindle to be tested and it is fitted in the gauge (female) and rotated once or twice. If persian blue *marks do not rub off evenly,* the *taper is incorrect* and setting must be adjusted until persian blue marks are rubbed equally all along its length.
- *Taper holes* can be checked by a '*Go*' *and* '*Not Go*' taper plug limit gauge as shown in Fig. 4.92. At the large end of the gauge where the large diameter of the taper hole should theoretically lie, a flat surface

is machined on the gauge on which two lines are engraved, the distance between them is equal to the tolerance on the base distance. The line nearer to the small end represents the '*Go*' limit and the other near the large end represents the '*Not Go*' limit of the taper hole. The *dimensional accuracy of the taper hole will be accepted when the taper gauge fits in the hole such that the "Not Go" limit remains outside the hole.* This *does not provide a positive check* of the type of contact between the mating parts along the whole length of the fits. These geometrical inaccuracies can be checked by marking light lines with persian blue as explained earlier.

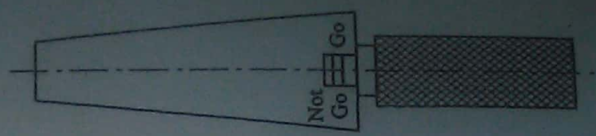
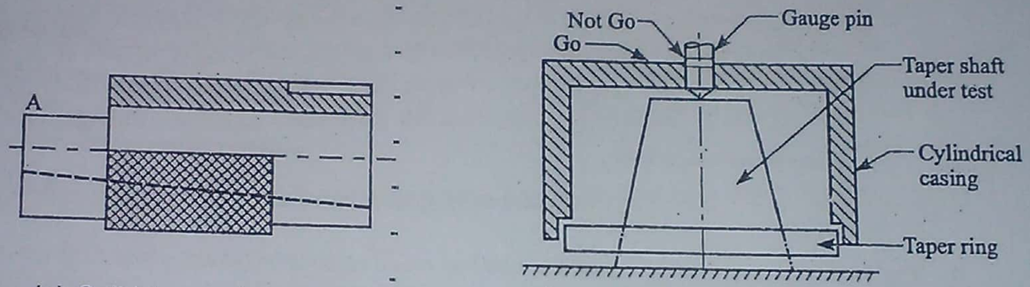


Fig. 4.92.

- *Taper shafts* can be checked by the reversible procedure using taper hole gauges as shown in Fig. 4.93(*a*, *b*). The *solid taper sleeve gauge* [Fig. 4.93(*a*)] has cut away portion A, on which the "*Go*" and "*Not Go*" limits are engraved. By inserting the taper shaft in the hole gauge, the small end of the taper shaft should lie between these two limits. The geometrical accuracy of the shaft can be checked by the persian blue procedure.
- The *taper ring gauge* [Fig. 4.93(*b*)] consists of a taper ring that can be placed on the taper shaft under test. A cylindrical casing is mounted on the taper ring and the position of the taper ring relative to the small end of the shaft can be checked by a gauge pin on which "*Go*" and '*Not Go*" limits are marked. To check the geometrical accuracy of the taper shaft, more than one taper ring should be used.



(a) Solid taper sleeve gauge. (b) Taper ring gauge.

Fig. 4.93.

A positive check of the dimensional and geometrical accuracies of taper shafts can be achieved by using "*May*" *taper gauge* [Fig. 4.94). It consists of two similar side members separated by a standard central taper gauge. The taper gauge is provided with a taper work support on which the taper shaft has to rest. The height of the work support is made such that the two side members make contact with the taper shaft at two enveloping lines diametrically opposite. The two side members and the taper gauge are made separate for the universal use of the gauge and they can be screwed together. On the top surface of one of the side members the two "*Go*" and "*Not Go*" limits are provided within which the large diameter of taper shaft should lie. Geometrical

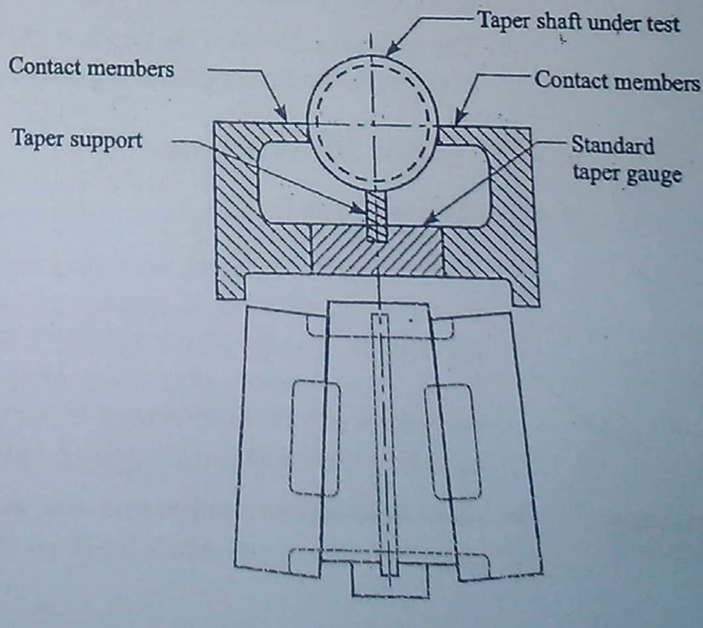


Fig. 4.94.

balls can be measured by means of slip gauges blocks which should be inserted without force to avoid errors. The two balls are then placed on equal columns of slip gauges of height h and the distance L_1 separating the balls is also measured with slip gauges. The taper angle then be calculated as follows :

$$\tan\alpha = \frac{L_2 - L_1}{2h}$$

C. Measuring a taper hole on the sine table using internal adaptor : Fig. 4.100 shows the set-up for measuring a taper hole on the sine table using internal adaptor. The internal adaptor used consists of a hollow cylinder with suitable external diameter and a lever, hinged in the cylinder, whose magnification ratio is 1. The taper ring as placed on one of the centres and adapter is made to contact the bottom surface of the taper hole. The sine table is adjusted by slip gauges until the lower surface of the taper hole is set parallel to the surface plate. This can be ensured when the reading of the dial gauge, in contact with the adaptor, remains constant during the axial movement of the adaptor inside the taper hole. In this position, the angle made by the sine table is equal to the taper angle, angle of the component being tested.

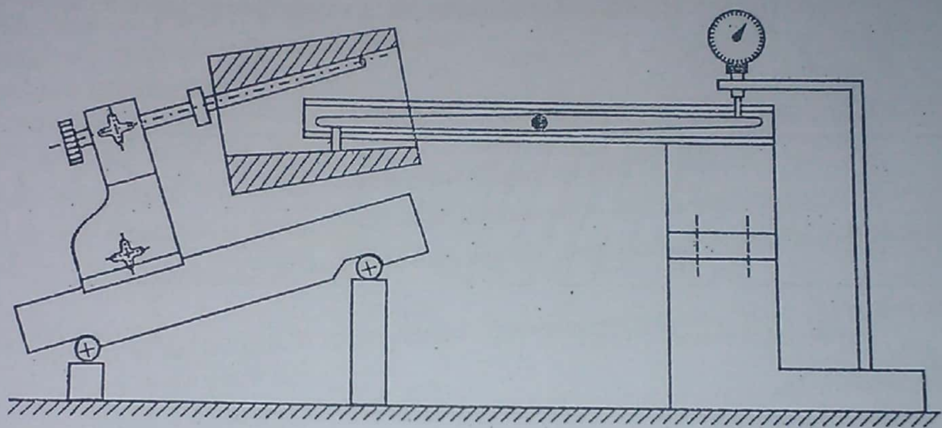


Fig. 4.100. Set-up for measuring a taper hole on the sine table using internal adaptor.

4.5. SCREW THREAD MEASUREMENTS

4.5.1. Introduction

A screw thread is helical ridge formed on uniform section round the curved surface. The shape of the normal section of the thread depends upon the shape of the tool which produces its groove. A screw is a male threaded piece generally cylindrical in form, but sometimes, conical (or tapered), used in most cases as a temporary fastening; less frequently used as a means of transmitting motion or power.

The screw threads are applied to many devices for various *purposes* as follows :

1. To hold parts together as in the case of fastening.
2. To transmit power.
3. To control movement as in micrometer.
4. To increase the effect of applied effort as in auto jack.
5. To convey materials as in the case of fastening.

4.5.2. Classification of Threads

The threads may be *classified* as follows :

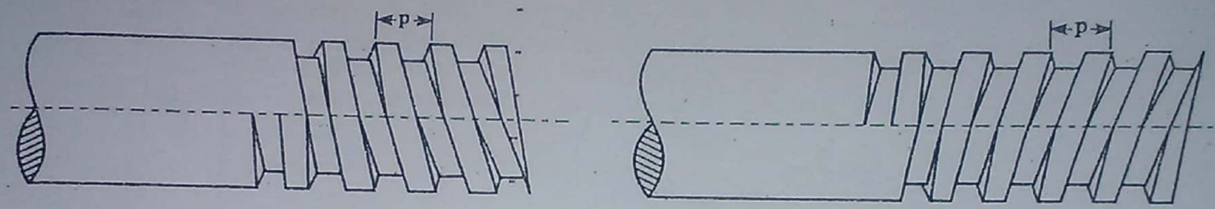
1. *According to the surface on which the threads are cut :*
   (*i*) External threads
   (*ii*) Internal threads.

   The external threads are cut into the surface of a *cylindrical bar.*

   The internal threads are cut into the surface of the *cylindrical hole* of a bar or cone.

2. *According to the direction of rotation of the threaded cylinder with respect to engagement or disengagement with the other part :*
   (*i*) Right handed thread
   (*ii*) Left handed thread.

   A *right handed thread* is one in which the nut must be turned in a right handed direction to screw it on (Fig. 4.101(*a*)). A left handed thread is one in which the nut would be screwed on by turning it to the left (Fig. 4.101(*b*)).



(a) Right handed thread. (b) Left handed thread.

Fig. 4.101.

3. *According to number of starts :*
   (*i*) Single start threads
   (*ii*) Multi-start threads.

In a piece of work it is possible to have separate and independent threads running along it. Accordingly, there are single threaded screw and multiple or multi-start threaded screw. The independent threads are called starts and we may have single start, two start, three start etc. (Fig. 4.102).

A *single start threaded screw* is one in which there is a movement of one thread for one complete turn round the screw or bolt. In the *multi-start threaded screw* there is a movement of more than one thread. In the case of double start thread, for one complete turn, the thread advances two times as if it were a single thread.

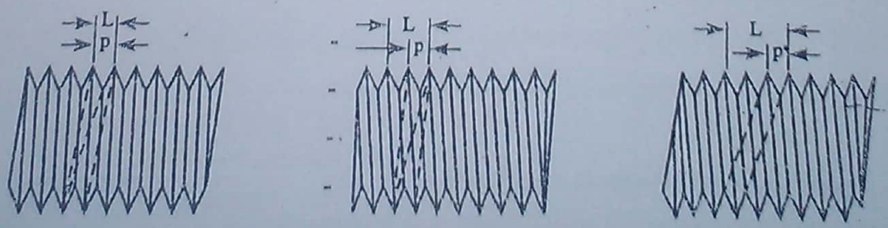


Fig. 4.102. (i) Single-start, (ii) Two-start, and (iii) Three-start threads.

Use of multi-start threads. Multi-start threads are used on those cases where *rapid movement or motion is required.*

Examples: Fountain-pen cap, screw press, bottles, tooth paste etc.

4.5.3. Elements of Screw Threads

To designate different parts of the screw threads the following *terms* are commonly employed :

Refer Fig. 4.103.

1. **Major diameter.** It is the *largest diameter of a screw thread.* It is also termed as *outside* or *crest diameter.*
2. **Minor diameter.** It is the *smallest diameter of a screw thread.* It is also known as *root* or *core diameter.*
3. **Effective or pitch diameter.** It is *an imaginary diameter in between the major and minor diameters, and is equal to the major diameter less than an amount equal to the single depth of a thread.*

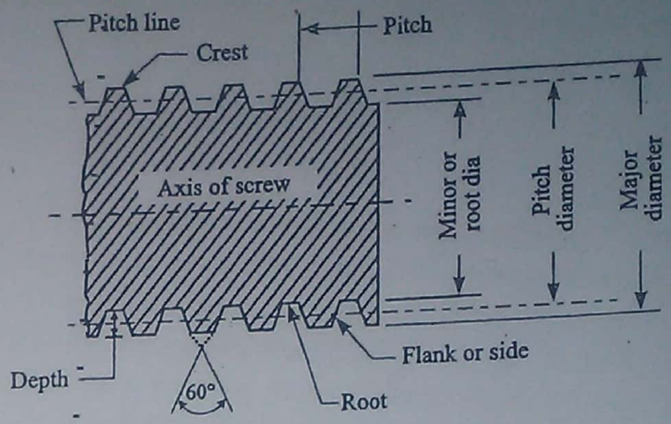


Fig. 4.103. Nomenclature of a screw thread.

4. **Axis of screw.** It is the *longitudinal central line through the screw.*
5. **Angle of thread.** It is the *angle between the two sides of a thread measured in an axial plane.*
6. **Depth of the thread.** It is the *angle between the crest and the root of a thread measured normal to axis.*
7. **Thickness of the thread.** It is the *distance between the adjacent sides of the thread measured along or parallel to the pitch line.*
8. **Side.** It is the *slant surface of the thread which connects the crest with the root.*
9. **Helix angle.** It is the *angle made by helix of the thread at the pitch or effective diameter with the plane perpendicular to the axis.*
10. **Crest.** It is top *surface joining the two sides of a thread.*
11. **Root :** It is the *bottom surface joining the two sides of a thread.*
12. **Pitch.** *It is the distance from a point on one thread to the corresponding point on the next thread measured parallel to the axis of the thread.* It is denoted by '*p*'.
13. **Lead.** *It is the distance a screw thread advances axially in one turn on a single thread screw, the lead is equal to pitch and for a double threaded screw, the lead becomes two times the pitch and so on.*

Note : A screw is specified by a *nominal diameter,* it is the diameter of the cylindrical piece on which the threads are cut.

4.5.4. Specifications of a Screw Thread

To specify a screw thread the following points are given due considerations :

1. Shape or form of thread
2. Pitch
3. Size (diameter)
4. Length
5. Number of starts
6. Material
7. Direction of threads
8. Internal or external threads.

Unit V

UNIT III

Metrology

What is Metrology
It is science of measurement.

Purpose of meterology:
i) establishing the units of measurement
ii) developing methods of measurement.
(iii) Analysing the accuracy of methods of measurement.

Causes of Error:
Static Error
1) Reading error:
(a) Parallex or optical resolution
b) Characteristic errors: It is defined as the deviation of the output of the measuring system under constant environmenta conditions from the therotically predicted performance or from nominal performance specification.

(c) Ambient Error.

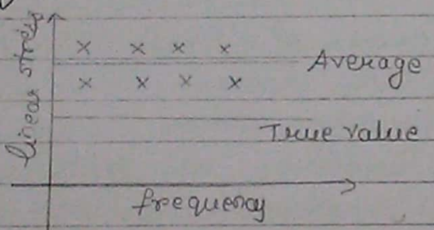
Errors are also categaries as:
(a) Controllable Error
b) Random Error

Controllable | Random

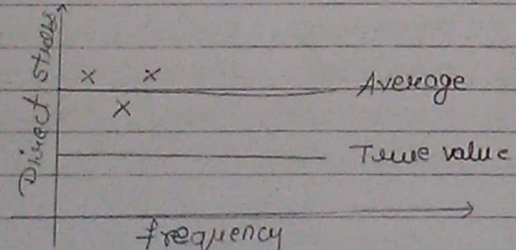
1) Calliberation
2) Ambient
3) Stlas pressure
4) Avoidable error
- Parallox
- Alignment
- location.

Accuracy & Precession:

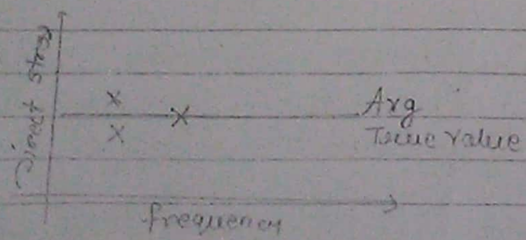
Precise but not accurate



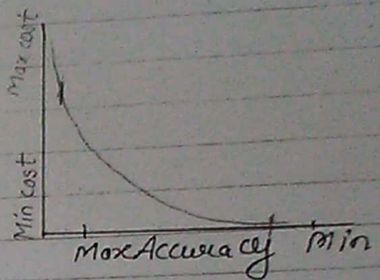
Accurate but not precise



Accurate & Precise



Accuracy & cost



① Caliberation standards:
2) Work piece
3) Instrument
4) Person
5) Enviornment

★ Factors affecting measurement (SWIPE)

Classification of methods of measurement
1) Direct method of measurement.
2) Indirect method of measurement (with the help of mathematical calculation)
3) fundamental "
4) Comparision "

★ Classification of measuring instrument
① According to function
ⓐ length measuring instrument
b) Angle measuring "
ⓒ Instrument for checking deviation from

I

geometrical forms.

d) Instruments for determining quality of surface finish.

② According to Accuracy

i) most accurate instruments
light interference instruments.

ii) Less accurate instruments
comparators. tool room microscope, optimeters

iii) Still less accurate instrument.
Vernier Callipers & dial indicators.

Linear measuring instrument.
inside, outside, spring calliper, hermophrodite calliper, surface plate, angle plate, straight edge, combination gauge, radius gauge & fillet.

Legal metrology :-
The function of linear metrology are
- to ensure conservation of national standards
- to the accuracy with international std.
- to guarantee & where necessary & to impart proper accuracy to secondary standards being used in the country
- to regulate, advice, control & supervise manufacturing & repair of measuring instrument
- to inspect measurements & operation of instruments
- to detect fraud of measurement.

Standards of measurement :-

a) Material standard → Line standard / end standard

b) Wavelength standard.

Line Standard :- When the length is measured as the distance between centres of two engraved lines.

End standard :- When the length is measured as a distance between two parallel faces

Wavelength standard :- The wavelength of a selected orange radiation of krypton 86 isotope was measured & use as a basic unit of length.

differentiation between line & end standard

Difference

Sr no.	Characteristic	Line standard	End standard.
1)	Principle	length is expressed as dist. betn two lines.	length is expressed as distance betn two parallel faces or flat
2)		±0.2mm	limited to 0.001 mm
3)	Ease	quick & easy	time consuming & required skill
4)	Effect of wear	wear at ends only	wears at measuring surfaces
5)	Alignment	cannot easily alligned	easily alligned.
6)	Cost	Low	high.
7	Parallex effect	subjected to Parallex effect	not subjected to Paraller effect.

Unit VI

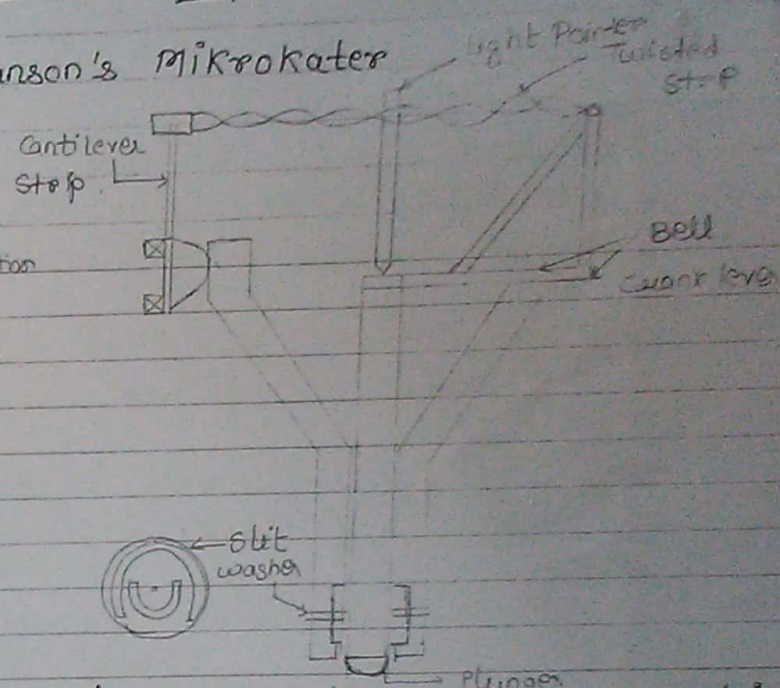
Comparators :-

Comparators are of various types.

1) Mechanical
2) electrical
3) Electronics
4) Pneumatic etc.

1) Mechanical Comparator :-

Johanson's Mikrokater

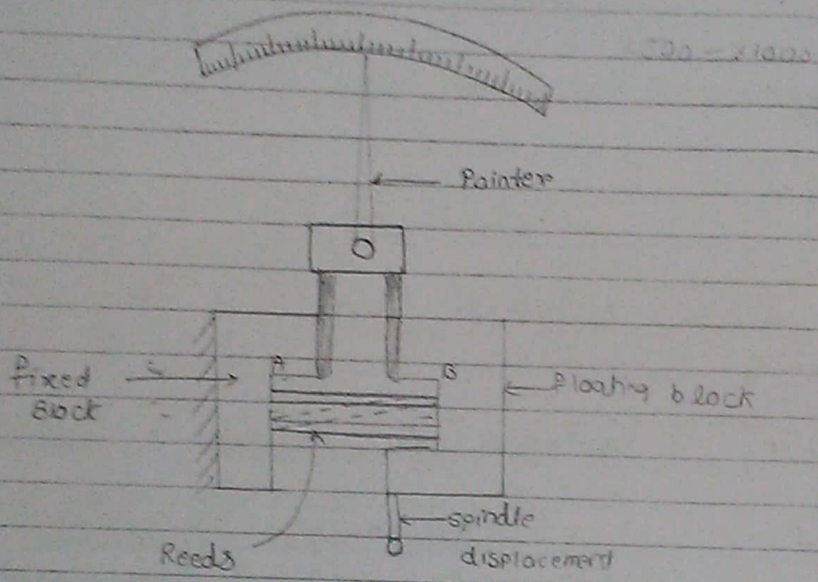


System of displacement amplification used in comprators

1) Rack & pinion
2) Cam and gear train
3) Lever with ~~two the~~ toothed center
4) Compound lever
5) Leverested taut

Lever combined with band wound around drum
Reeds combine with optical display
Tilting mirror projecting light spots.

2. Reed type mechanical Comparator :

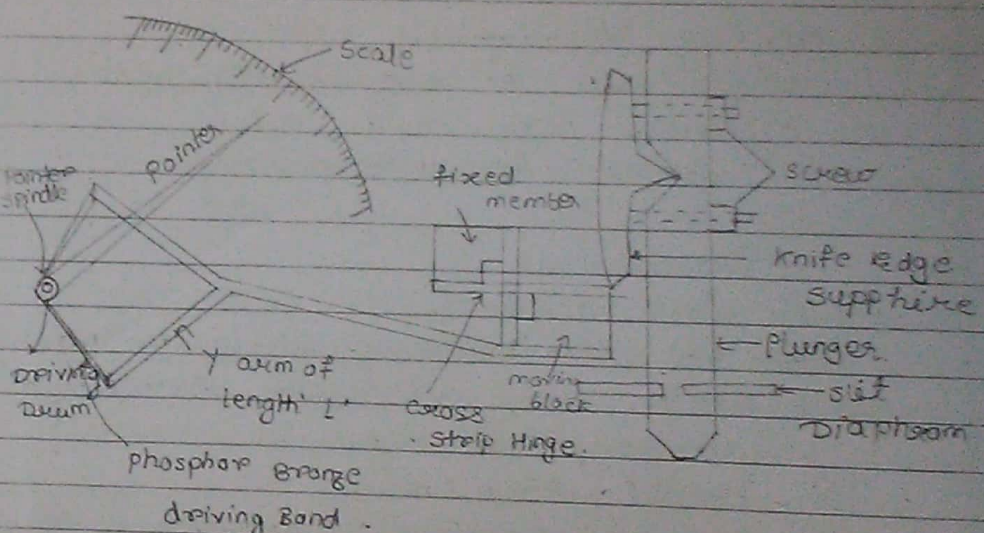


3 ~~Sigma Com~~

i) Fig. shows reed type mechanical comparator.
ii) Reed mam is frictionless device for magnifying small motions of this spindle.
iii) It consist of two blocks, fixed block A & Floating block B. connected horizontally with
iv) horizontal reed.
v) A vertical reed is attach to each block with upperends joint together.
v) A linear motion of the spindle moves the free block vertically causing the vertical reed on the floating block to

slide.
vi) As these reeds are joint at the upper end the movement causes change in pointer position.
vii) The amount of pointer swing is propotional to the distance of the floating block has moved. But of course very much magnified.

3. Sigma Comparators :



1. The plunger is mounted on a pair of slit diaphragms in order to have frictionless free movement.
2. Knife edge is mounted on moving block of cross strip hinge. The cross strip hinge consist of moving block & fixed member.

If the external force is applied to a moving member it will pivot about the line of intersection of strip.

8. Moving block is attached to Y-arm. on the Y-arm phosphorous Bronze driving band is attached in which a driving drum along with a pointer is placed, for showing minute displacement of the plunger.

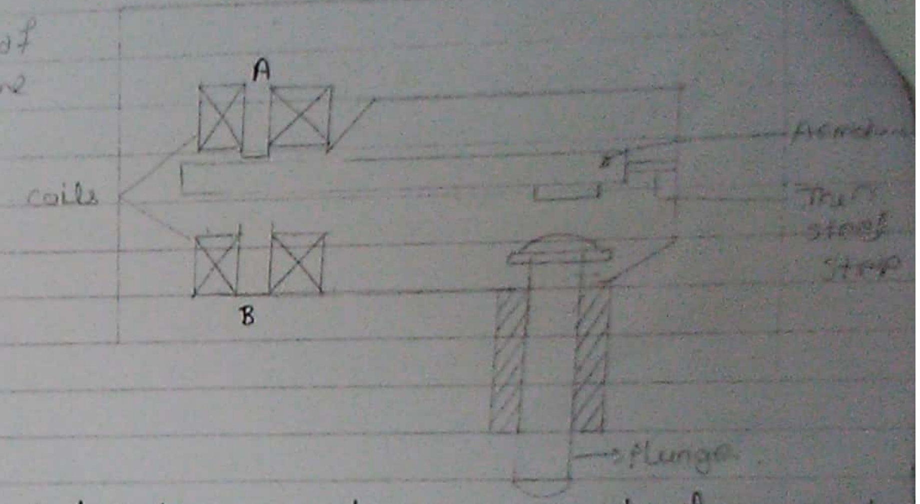
Advantages
1) easy to operate
2) robust & easy to handle
3) chip.
4) Suitable for workshop condition.

Disadvantage
1) less accuracy
2) due to slackning of certain moving parts such as reeds or bronze band accuracy get affected.
3) limited scale range
4) Because of inertia, vibrations cause affecting accuracy.

phosphorous Bronze driving band → It reduce slackning as compared to rubber band, also helps to show readings in microns with less friction

★ Electrical Comparators :-

Principle of Wheatstone bridge



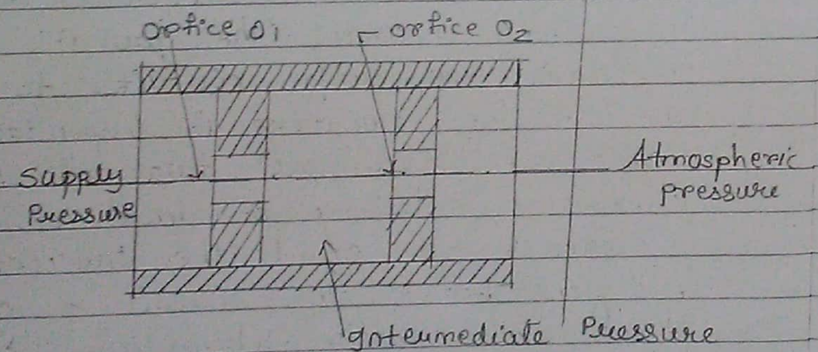
In electrical comparator, movement of measuring contacts, is converted into electrical signals. This electrical signal is recorded by an instrument which is caliberated in terms of plunger movement. The principle is based on wheatstone bridge circuit. As shown in the fig. The armature is suspended on a thin steel strip betn two coils A & B. When the distance of armature from both the coils is equal the current does not flow in the circuit & galvanometer shows no deflection. Whenever the plunger moves the armature which in turns disturb the distance of armature betn two coils the current starts moving in the circuit showing deflection in the galvanometer.

Advantages of electrical Comprator

1). Less no. of moving parts.
2) quick response with accuracy
3) High Amplification
4) More accurate then mechanical comparator.

1. It requires external supply
2. ~~Volt It Variation~~
2. Variation in current & Voltage affects the accuracy.
3. Cost is high.
4. not More susceptible to vibrations.

3 * Pneumatic Comparators :-



The pneumatic comparator uses air flow or pressure to measure deviation from the standard, the response of the comparator will be quicker then

those working on air pressure. The pneumatic gauging is based on bernoulli's theory. As shown in fig. if air at a low but constant pressure, P_s is allowed to flow through a small jet or orifice O_1 into an intermediate chamber & then through a second orifice O_2 to atmosphere, then the intermediate pressure P_i in the intermediate chamber will depend on the relative sizes of two orifices. Since, the flow of air through two orifices is the same, the pressure drop across them will depend on the resistance they offer (because of sizes). If the size of orifice O_1 is kept constant then the change in P_i will depend upon the variation in the size of orifice O_2.

Advantages of Pneumatic Comparators :-

1. The gauging member does not come into contact with the part to be measured, hence, no wear & tears.
2. It has usually very small number of moving parts.
3. Possible to have high magnification.
4. Indicating instrument can be placed at a remote place.
5. Suitable for measuring diameters of hole

X

where the diameter of hole is less the length of the hole.

1). Requires auxillary equipment.
2. Not easily portable
3. Different gauging edge for different gauging size dimensions,

UNIT I

Classification of Operations :-

BASIC OPERATIONS :- They are known as blank making process.

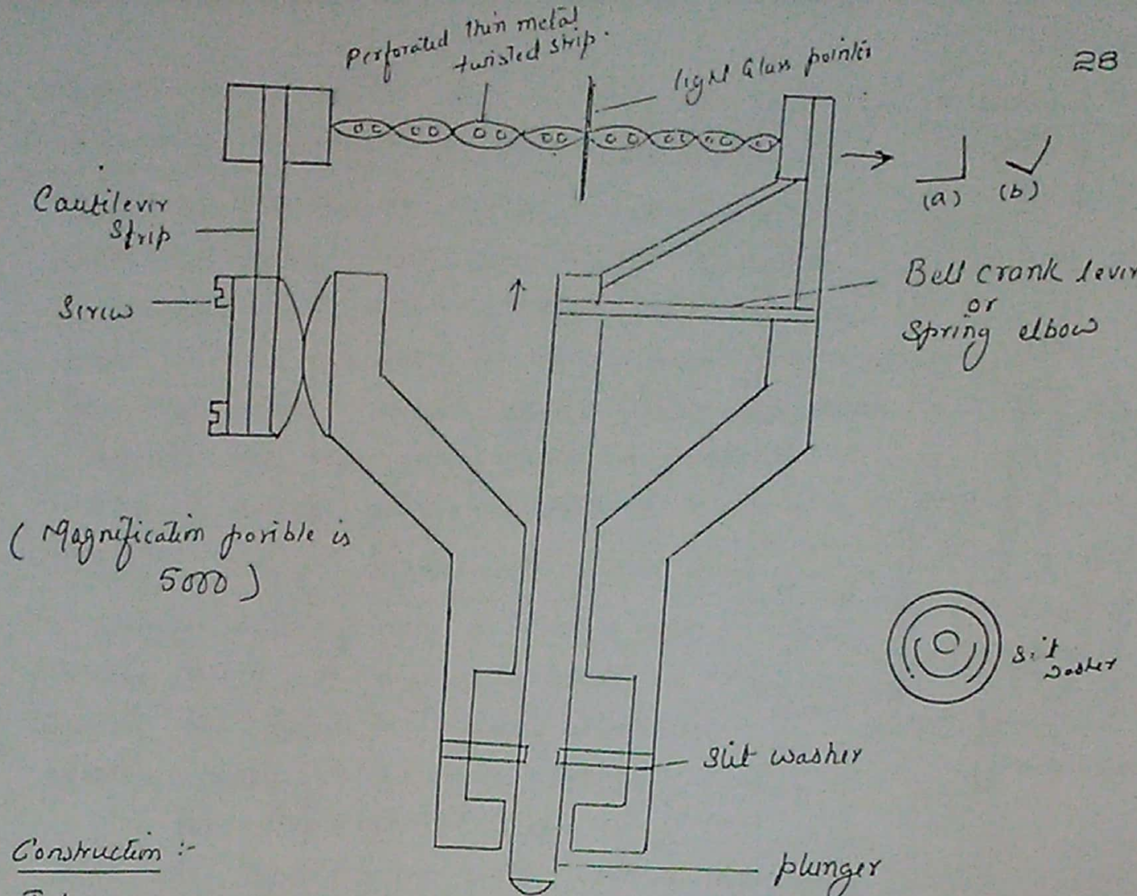
Basic process operations are some time known as founding operations. Basic proc. operation are those which gives the material its initial shape. Some of the basic operation are

1) Casting (Sand Casting)
2) Forgeing
3) Rolling etc.

The basic process operation are usually of specified nature aquiring large facilities hence, they are processed by basic industries.

MAJOR OPERATION :- All the operation needed to generate the shape of on geometric & ______ mechanical pt. of view. The major operation can be classified as Critical operation, secondary operation, Qualifying operation & Requalifying operation

(a) Critical Operation :- Critical operation can be divided into two parts :-



Construction :-

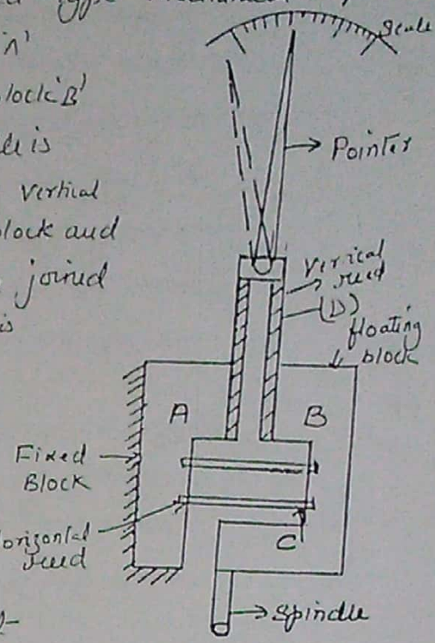
Johansson mikrokator consists of plunger, Slit washer which controls the lower movement of plunger. Spring elbow is attached to ~~other~~ end of plunger, to the other arm of spring elbow is attached half twisted metal strip which is perforated. A cantilever strip which carried the other half of twisted metal strip. The two halves of twisted metal strip in it's centre carries a light glass pointer and are twisted in opposite direction.

Working :- Place the standard below the plunger. due to which plunger moves upwards. As the plunger moves upwards it lifts the bell crank lever also upwards due to which the bell crank lever on the other end tilts. During this tiltation of arm of bell crank lever it stretches which causes twisted metal strip which is attached to arm of lever to rotate hence the glass pointer also rotates whose reading can be noted. (During which the twisted metal strip will be untwisted)

Secondly replace the Standard and place the object; if the size of object is greater than that of Standard, then the plunger moves upwards by more amount than earlier due to which [illegible] bell crank also lifts more and tiltation is more so the twisted metal strip will be untwisted again but now it will be more as compare to that of earlier. Note down the reading of pointer. The difference in two readings gives the difference between standard and object.

The magnification of Johansson mickrokator depends on Length of strip which can be adjusted by the help of cantilever strip and width of metal strip and no. of twists of twisted metal strip.

Explain the Construction and working of Reed Type mechanical comparator.



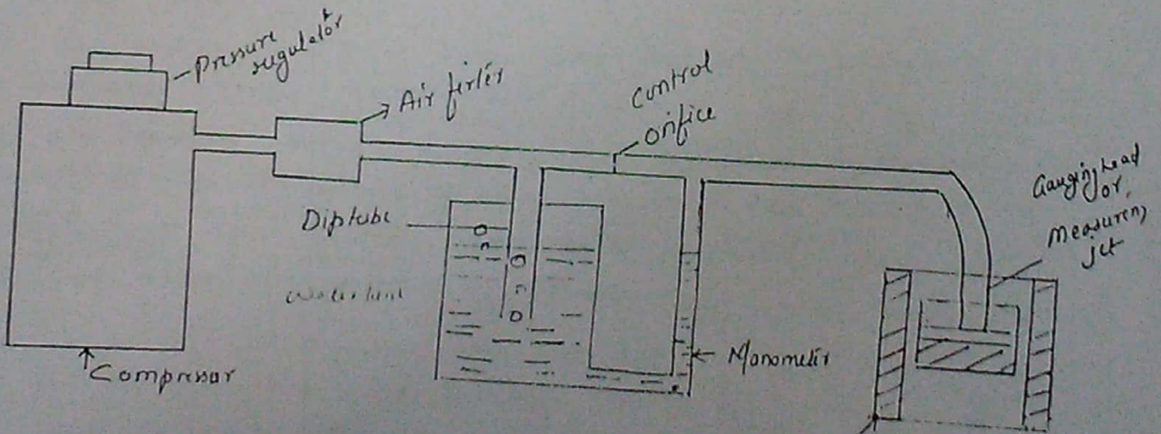
Construction :- It consists of fixed block 'A' which is fastened to floating or moving block 'B' with the help of horizontal reeds. Spindle is connected to this floating block. A vertical reed D is attached to both fixed block and floating block whose upper ends are joined together. On this joining surface a spindle is there to which pointer is attached.

Working:- Any displacement when given to spindle after placing a standard causes floating block to move upwards. During this the vertical reed attached to floating block also moves upwards but ∴ as this vertical reed is joined at the top together with vertical reed of fixed block which causes the vertical reed to swing instead of moving upwards. During this swing the linear displacement is magnified at one stage. Now the spindle which is on the surface of joining of two vertical reed rotates causing the pointer on it to show the magnifying displacement on scale. Note down the reading.

Replace the standard to that of an object and repeat the same procedure and note down the reading.

The difference in two readings gives the difference between standard and object.

Explain the Construction working of Solex Pneumatic Comparator.



Solex Type pneumatic comparator consists of Air compressor, pressure regulator to supply constant pressure of air, air filter, dip tube which is immersed in water, tank or cylinder. A calibrated manometer connected to water tank, control orifice to control the pressure variation in air, measuring jet or Gauging head

Later replace the 'standard with object now if the size of object is greater than that of standard the plunger will move more vertically due to which the knife edge comes down giving more space for mirror to tilt because of which the index is reflected on inner surface of ground glass screen which can be visualised from front. Note down the reading. The difference in two readings will give us the comparision between standard and object.

→ Explain the construction and working of optical Comparator (Zeiss).

This is a commercial measuring instrument consists of plunger, tilted mirror, objective lens, prism and observing eye piece to provide a high degree of magnification. As shown in the

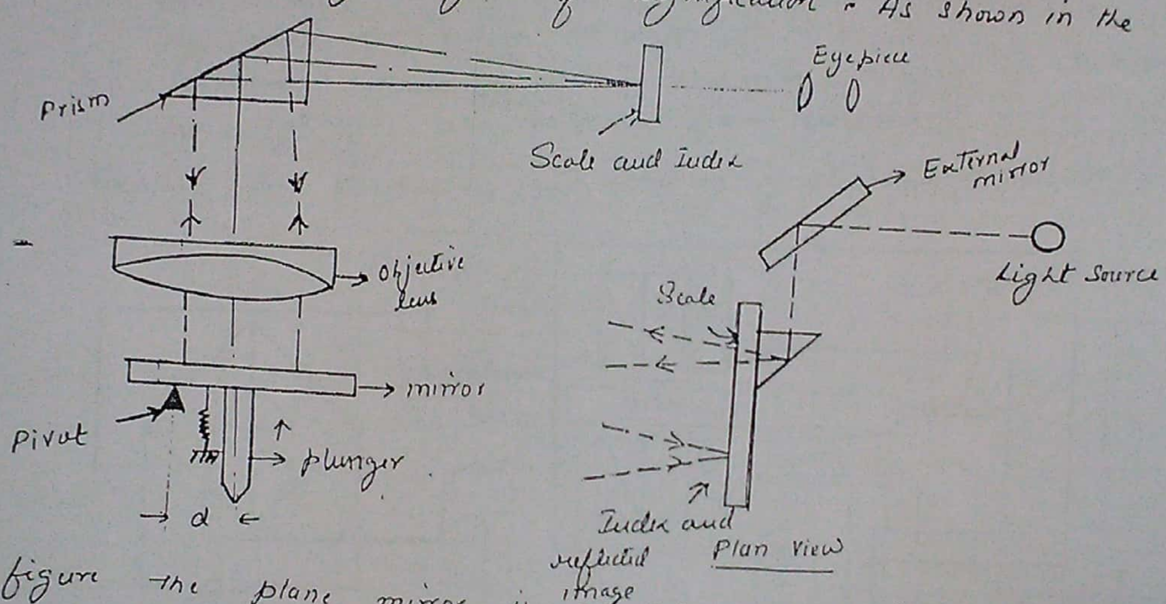


figure the plane mirror is mounted on a knife edge and it can be tilted about its fulcrum by any linear movement of the contact plunger.

Working:- In ordinary condition when you put on the instrument we can see only index through eye piece.

Place a standard below plunger due to which mirror is tilted about its pivot because of which now the scale which is carried by rays can now be seen as a reflected image across the index as shown in plan view through eye piece, reading is taken.

Now replace the standard to that of object and if the size of object is greater then the plunger moves by more amount vertically due to which the mirror will tilt by more amount and due to this the reflected image is seen at some different position across the index line. The reading is noted.

The total magnification is

$$\text{Eye piece magnification} \times \frac{2f}{d}$$

where f is focal length of lens & d is distance between knife edge & plunger.

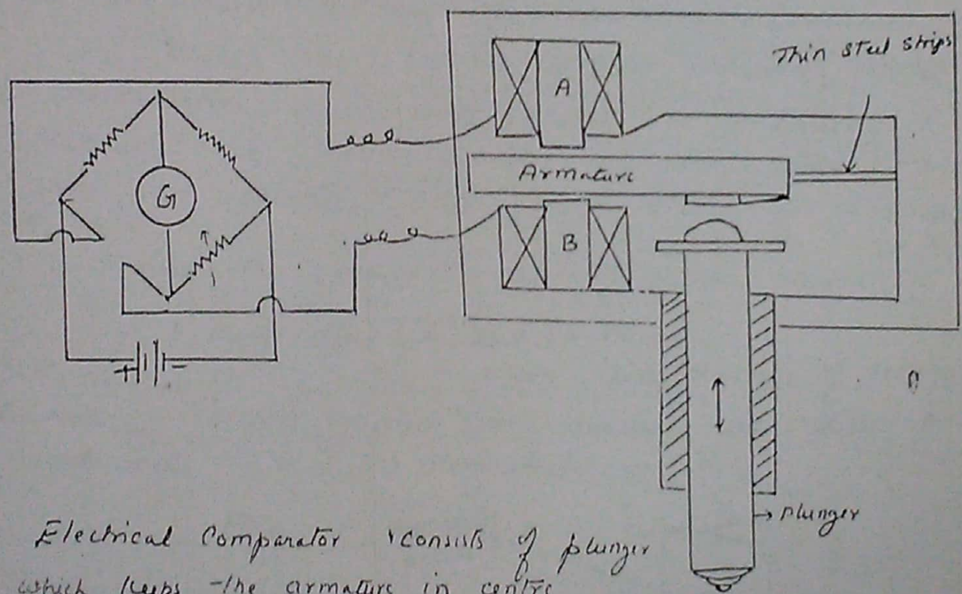
Advantages of Optical Comparator:

1. High accuracy :- These Comparators have very few moving parts and hence gives higher accuracy.
2. No parallax error :- The scale can be read over a datum line
3. High magnification
4. Optical lever is weightless.
5. Illuminated scale — since scale is illuminated, it enables readings to be taken irrespective of room lighting condition.

Disadvantages :-

1. Depends on external electrical power supply.
2. Instrument is bulky and expensive
3. Due to high magnification, heat from lamp, transformers etc may cause the setting to drift
4. Instrument should be used in dark room, therefore it is inconvenient for continuous use as viewed from eyepiece.

Explain the Construction and working of Electrical Comparators.



Electrical Comparator consists of plunger which keeps the armature in centre connected with the help of thin steel strips. This armature is also suspended between two coils A and B. This coils are connected to Wheatstone bridge and the galvanometer of this bridge is calibrated in a manner to record the movements of plunger when the bridge is unbalanced

working :- When vertical displacement is given to plunger by placing standard which results the armature displacement from two coils (now the armature is not in centre) therefore the bridge gets unbalanced and current flows through galvanometer. Reading is noted. Replace the standard with object again repeat the same procedure and note the reading. The difference between two readings gives the comparison between standard and object.

Electrical comparator have minimum moving parts therefore gives high degree of reliability. magnification are possible with these

Minor diameter :- It is defined as the diameter of an imaginary co-axial cylinder which touches the roots of an external thread or/and crests of an internal thread. Minor diameter is also called as root diameter or core diameter.

Effective diameter :- It is defined as the diameter of an imaginary co-axial cylinder which intersects the flanks of threads in such a way that the width of threads (i.e metal) and width of spaces between threads are equal.
[width of metal & spaces each being equal to half the pitch]

- Describe how the major diameter of an screw thread (external) can be measured.

→ Major diameter of an external thread can be measured by two instruments one by good quality micrometer and second by Bench Micrometer.

For measurement of external threads major dia - first we have to select setting cylinder whose diameter is approximately same or nearer to that of screw threads (external) major dia.

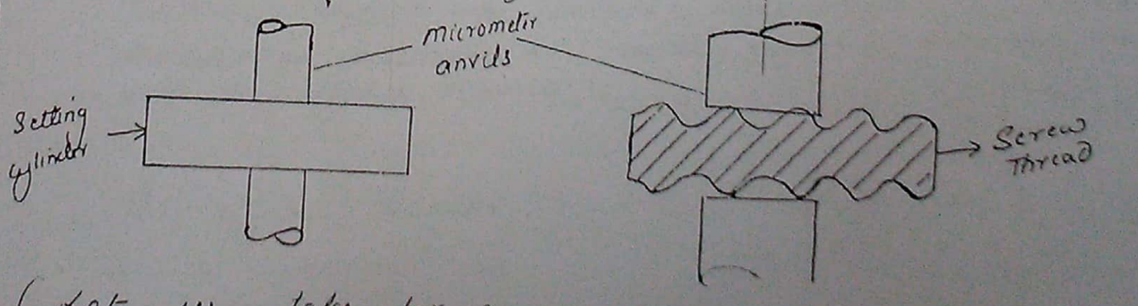
Place the setting cylinder between anvil and spindle of micrometer and note down the reading 'R_1'. Then replace the setting cylinder by screw thread between the anvil and spindle and note down the corresponding reading R_2.

Now the major diameter of screw thread is equal to

$$\text{Major dia} = D + (R_2 - R_1)$$

where 'D' is diameter of setting cylinder

(Note :- Setting cylinders are available in different sizes of diameter which is engraved over it).



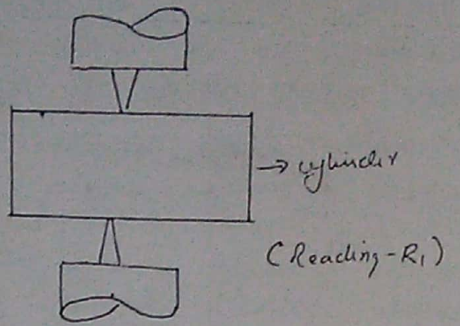
(Let us take for example diameter of setting cylinder is 20mm , Reading on setting cylinder $R_1 = 0.3$ mm and Reading on screw thread is $R_2 = 0.4$ mm.

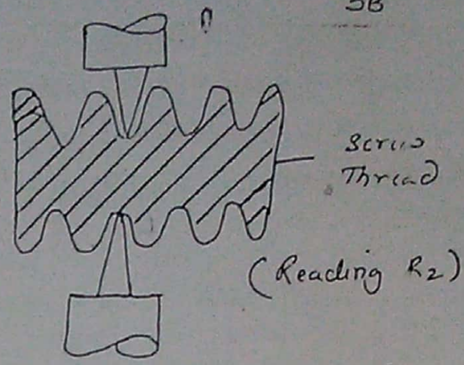
$$\therefore \text{Major dia of screw thread} = 20\text{ mm} + (0.4 - 0.3)$$

$$= \underline{20.10}\text{ mm}$$

The disadvantage in this system of measurement is there cause a deficiencies like variation in measuring pressure and pitch errors in its threads. Therefore to eliminate such sort of deficiencies a new instrument was designed by N.P.L. (National Physical Laboratory) with greater accuracy and convenience

Scanned by CamScanner





To detect the taperedness and ovality of screw-thread measurements are taken at different places.

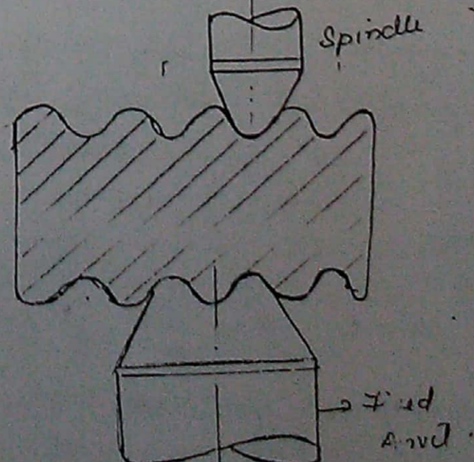
If the threads are very sharp or have no radius at the root, the measurment of minor diameter is done by projecting the thread form on a screen and comparing it with standard. The different 'V' pair are available on stand of floating carriage measuring m/c.

Explain how the effective diameter of a screw thread is measured.

→ The effective diameter of screw thread is measured by i) Thread micrometer method and ii) By Floating carriage-measuring machine by using two wires and three wires method (explained on the page of m/c.)

Thread micrometer consists of a fixed anvil which has an internal 'Vee' groove and a spindle of threaded micrometer is pointed with a 'V' cone of 60°. Before taking any reading first the spindle is rotated and engaged in groove to check zero setting and if there is any error now note down the reading. Then place the screw thread and operate the screw thread micrometer so as to engage the thread on side of root and second side on crest with spindle and anvil. Note the reading.

The difference in two readings gives the effective diameter. In this method the actual measurments is between major diameter on one side and minor diameter on another side - which gives the effective diameter.



The effective diameter can also be measured by Two wire and three wire method.

The wires are also available in different sizes with floating Carriage measuring m/c on a stand directions in horizontal plane with cross slide plates. There is a glass plate on work table on which the object is placed. There is another hollow vertical column on which optical head is mounted which can be adjusted at any position to proper focussing over the work by the help of clamping screw. There is a eye piece containing cross line engraved on glass screen which can be rotated through 360° whose angle of rotation can be read through an auxiliary eye piece provided on the optical head.

Working :- When the instrument is on and the object is placed over the glass plate of work table the ray of light from below the work table carries the image of object to the optical head by enlarging it due to the arrangement of prism and series of reflection which can be seen through the eye piece on the screen which is containing cross lines. Now in order to measure the angle match one of the cross line on flank of thread and it has to be considered as reference line and corresponding reading of auxiliary eye piece has to be noted. Then rotate the screen till the reference line comes in contact with another side of thread (flank). Stop rotating the screen. Note down the second reading. The difference in two reading gives angle of thread.

For measurment of pitch or depth of thread first match one of the cross line at one point of thread and note down the reading of micrometer. Later move the image by rotating the lateral micrometer till the corresponding point of adjacent thread is reached. Stop rotating the micrometer. Note down the second reading. The difference in two readings gives pitch of thread.

For depth of thread first match one of the cross line over the crest of thread and note down the reading of longitudinal micrometer. Then rotate the longitudinal micrometer till the root of thread reaches the cross line which is acting as reference line. Stop rotating longitudinal micrometer. Note down the reading. The difference in two readings gives depth of thread.

Note - Principle of tool makers microscope & optical profile projector is same. The difference lies in, eye piece is available in tool makers microscope where as there is glass screen which can be seen directly in optical profile projector.

In optical profile projector the standard profile is placed on screen with which comparisons can be made and also deviations of object with standard can also be known.

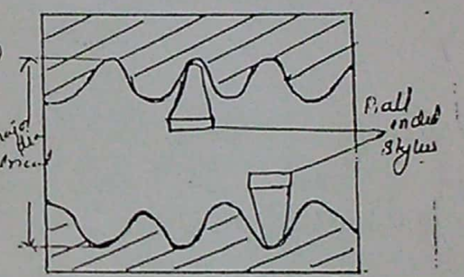
How the major diameter of an internal thread is measured ?.

The major diameter of an internal thread is measured with a thread comparator fitted with ball ended stylus of radius less than radius of the root of the thread to be measured. One end of stylus is attached to a floating head which is kept in contact with the plunger of dial indicator. The floating head towards the indicator is constrained by a spring.

First select the standard cylindrical reference having the diameter approximately equal to the major diameter of the internal thread to be checked. Note down the reading of dial indicator. Replace the standard with object and engage the instrument properly and note down the second reading of dial indicator.

Hence the major diameter of internal thread is now taken as $= D + (R_2 - R_1)$

D = diameter of standard cylindrical

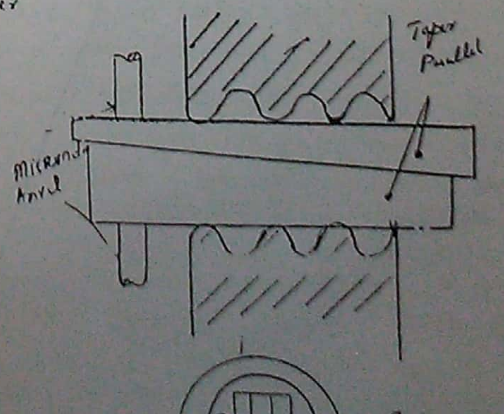


How the minor diameter of an internal thread is measured?.

→ minor diameter of an internal thread is measured by two methods ; one by using taper parallels second by rollers

Taper parallel method :- Taper parallels are pairs of wedges having radiused and parallel outer edges. The diameter across their outer edges can be changed by sliding them over each other.

In order to measure minor diameter first place one taper parallel on the crest of thread and then insert another taper parallel by sliding it over the first taper parallel till firm contact is reached. Now stop sliding and measure the outer diameter over the taper parallels with the help of micrometer. This method is suitable for small diameter of thread.



Using rollers For threads bigger than 20mm diameter precision rollers are inserted inside the thread and proper slip gauges are inserted between the rollers. The minor diameter is then the length of slip gauges plus twice the diameter of rollers