PRECISION MEASUREMENTS

MEASUREMENT CONCEPTS

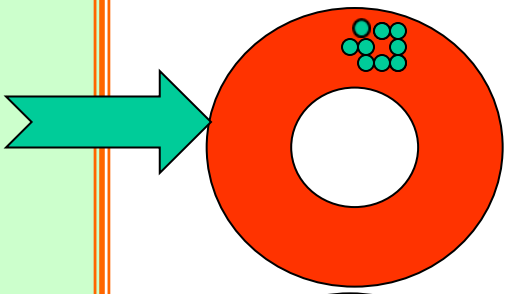
ACCURACY: Degree of agreement between measured size and the true value. Accuracy is the degree of closeness of measurements of a quantity to its actual true value.

REPEATABILITY/PRECISION: Closeness between two separate readings taken by the same person with a single instrument on the same part. Precision is the degree to which repeated measurements under unchanged conditions show the same result.

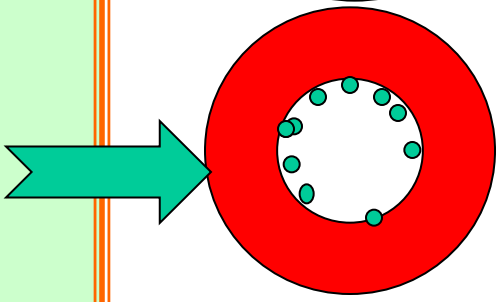
REPRODUCIBILITY: Closeness between readings taken by two or more persons with same instrument on the same part.

What is Precision ?

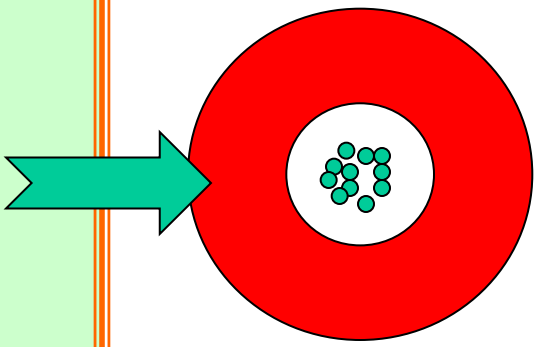
Precise but not Accurate



Accurate but not Precise



Precise and Accurate



Need for accuracy in Dimensional Measurement

- Greater Operational Precision
- Better Performance
- Greater Reliability
- Interchangeability
- Automatic Assembly

Factors Affecting Measurement

Repeated observations during Precision Measurement on a component under the same conditions shows different readings.

This is due to number Error Sources like

- **S Standard**
- **W Work-piece**
- **I Instrument**
- **P Person**
- **E Environment**

Error Source - Standard

- **Reference Standard may have an error**

Error Source - Work Piece

- **Burrs**
- **Deformation**
- **Form Errors**
- **Surface Roughness**

Error Source - Instrument

- **Graduation errors/ Pitch errors**
- **Non-linearity/ Zero shift**
- **Tilt/ bend/ wear**

Error Source - Person

- **Parallax Errors**
- **Worming up due to handling**
- **Use of more measuring force**
- **Over tightening**

Error Source - Environment

- Temperature
- Humidity
- Vibrations
- Atmospheric Pressure
- Air Turbulence
- Light Intensity
- Electrostatic Charges

Control On Environmental Conditions

Control and monitoring of following factors should be controlled and monitored as recommended:

- **Temperature (e.g. 25 +/-4.0 deg.C)**
- **Relative Humidity (e.g. </=70% RH)**
- **Illumination level (e.g. minimum 450 Lx.)**
- **Acoustic Level (e.g. max. 60 dB)**
- **Shock and Vibration should be adequately controlled**
- **Power supply Regulation (e.g. +/- 1%)**
- **Temperature gradient (e.g. 1.5 deg.C / hour)**
- **Proper earthling etc.**

Linear Measurement

- Linear measurement means that measurement of perpendicular **distance between two points or surface.**

- Its applies to measurement of **length, heights, diameters, thickness, radius etc**.

Classification of linear measuring instruments

A) Classification based on methods of measurement

- Direct measuring instruments
- Indirect measuring instruments

B) Classification based on the accuracy that can be obtained

- **Non precision instruments :** It includes Steel Tape, Scale, Calliper, Divider; Depth Gauge, Telescopic Gauge etc
- **Precision instruments:** It includes Vernier Caliper, Vernier Height Gauge, Vernier Depth Gauge, Micrometer, Slip Gauges, etc

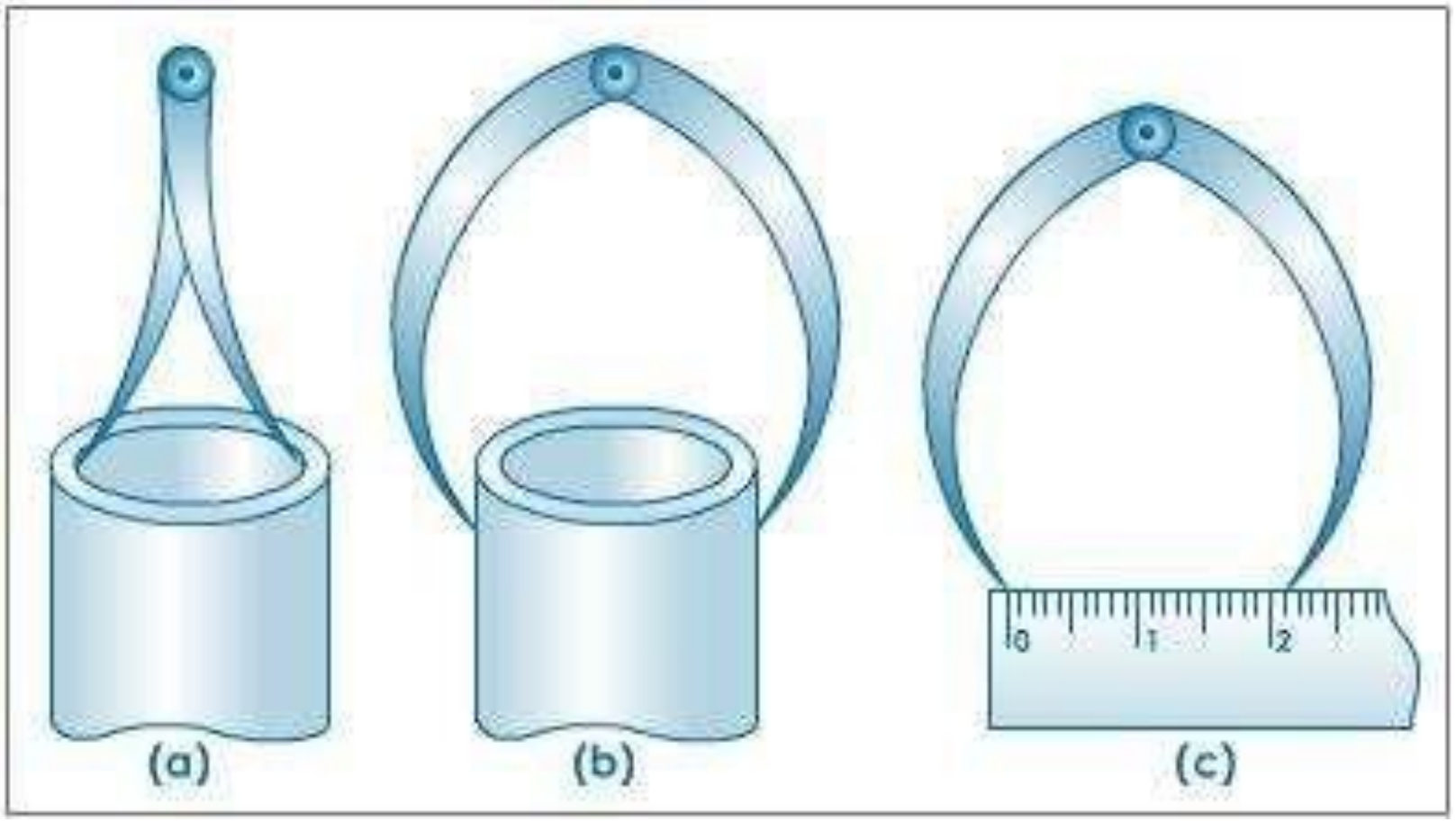
Non Precision Instruments

Outside Caliper

Inside Calipers

Divider Caliper

Non Precision Instruments - Use of Callipers

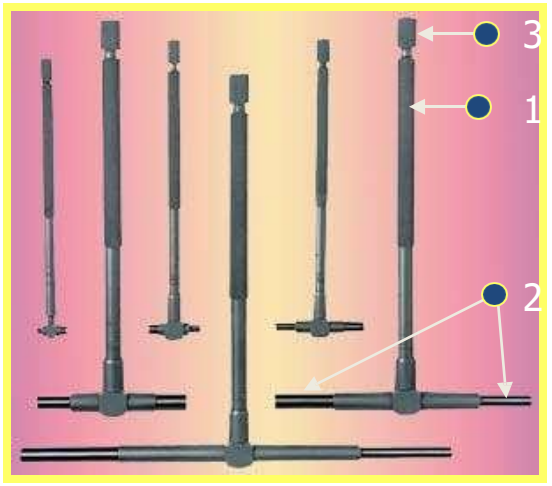


Telescopic Gauge

Use :- **Indirect measurement of Bore, Slot, Recesses, etc. Used in accordance with micrometer / Vernier.**

Parts :-

1. **Handle**
2. **Pair of Plunger**
3. **Lock**

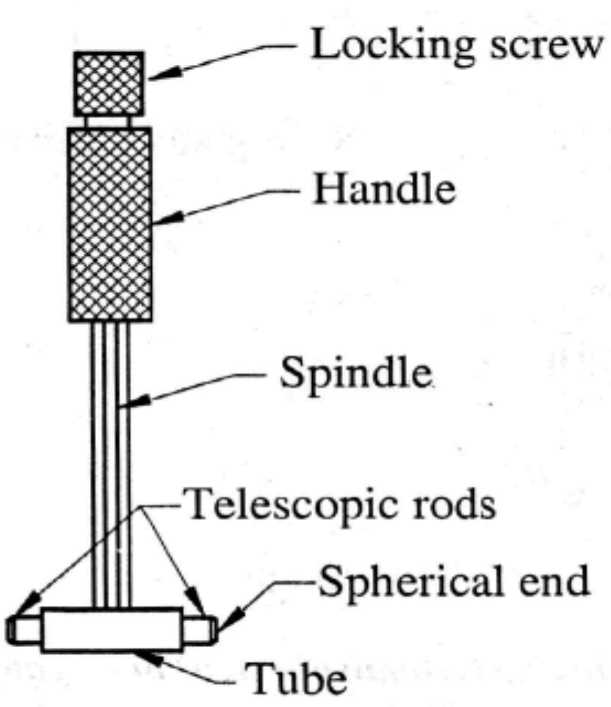


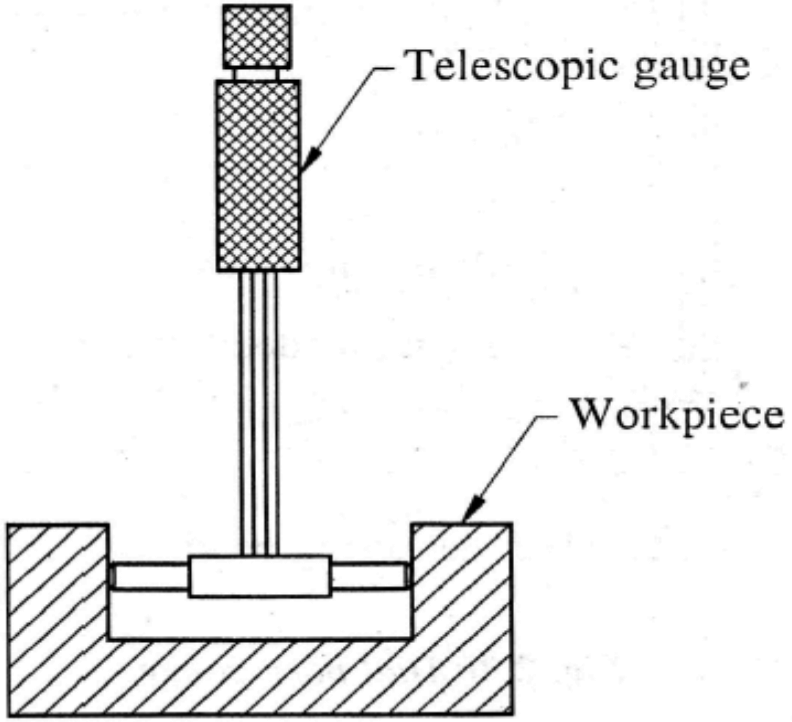
Construction:-

- **It consists of handle, two telescopic rods & locking screw**
- **For taking measurement, telescopic rods are compressed against spring & inserted into the hole whose diameter to be measured.**
- **Then extended up to the walls of hole.**
- **Then they locked by locking screw & rods can be measured by micrometer or vernier calliper.**

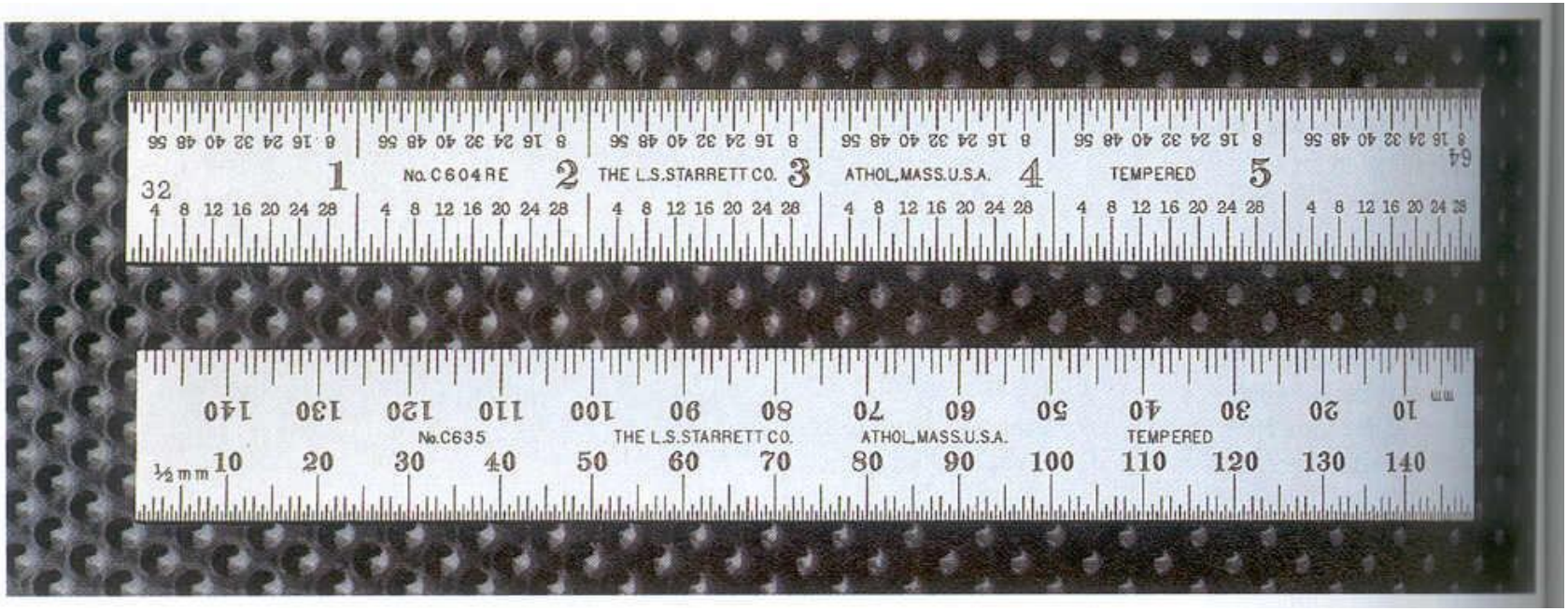
TELESCOPIC GAUGE

- **Indirect measuring** device
- Used for measuring **internal diameter of holes, slots and grooves etc**
- **Consists of** handle, two telescopic rods and locking screw



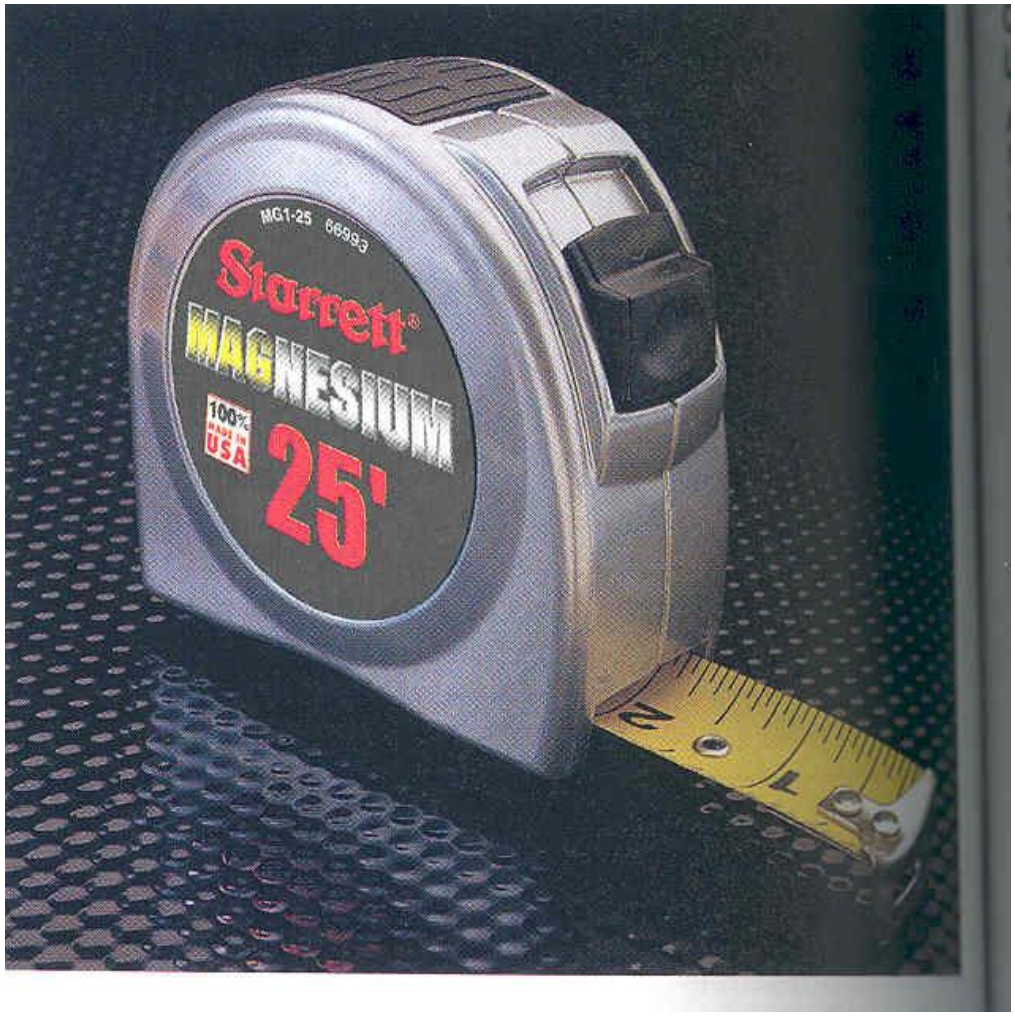


Non precision instruments - Scales



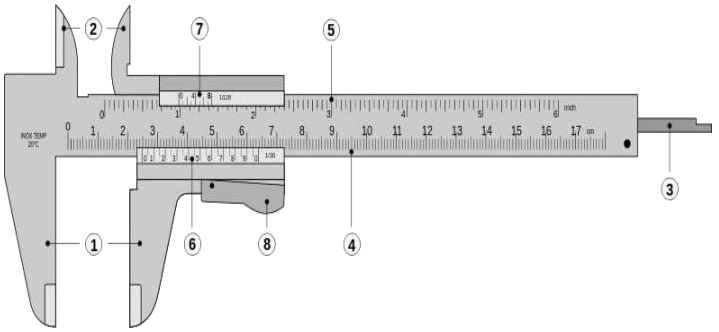
The Scale is an instrument used for measuring lengths directly with coarser accuracy

Non Precision Instruments - Tapes



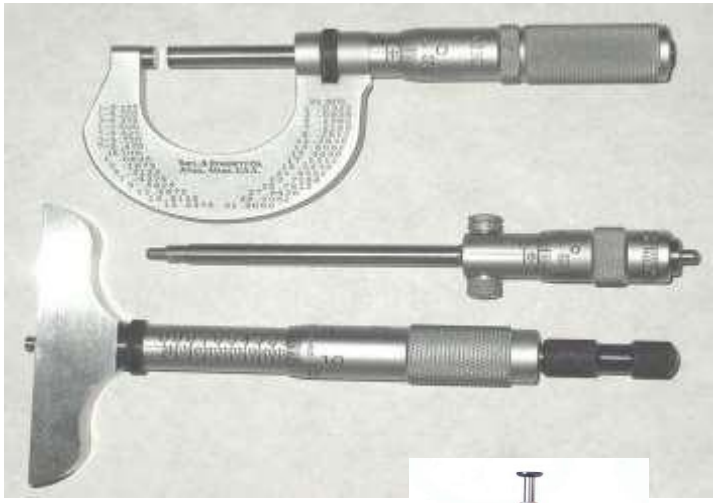
The Steel Tape is used for measuring longer lengths with coarser accuracy

Precision Instruments



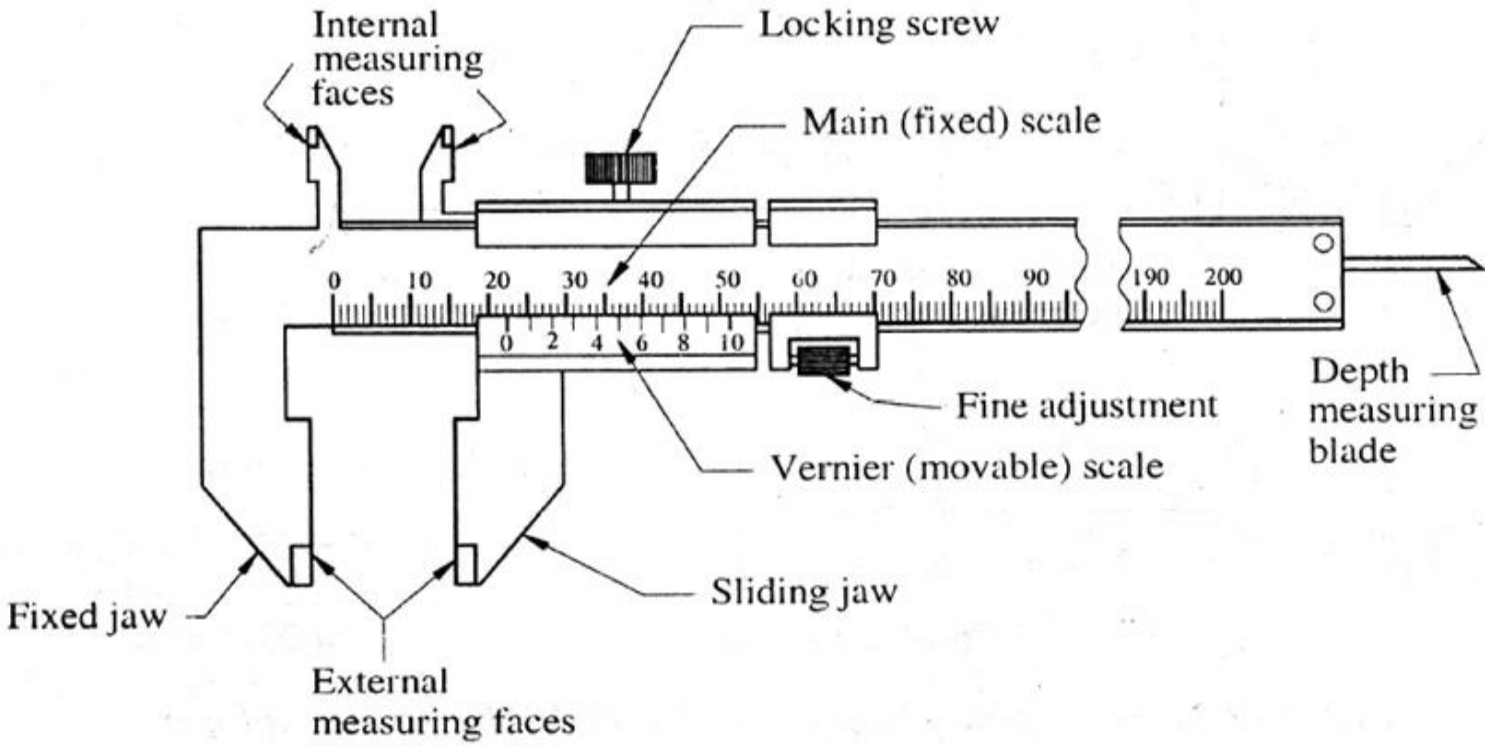
List of Precision Instruments

- Vernier Calliper
- Micrometer
- Vernier Height Gauge
- Dial Indicator
- Comparators
- Bore Dial Gauge
- Slip Gauges/Gauge Blocks
- Limit Gauges

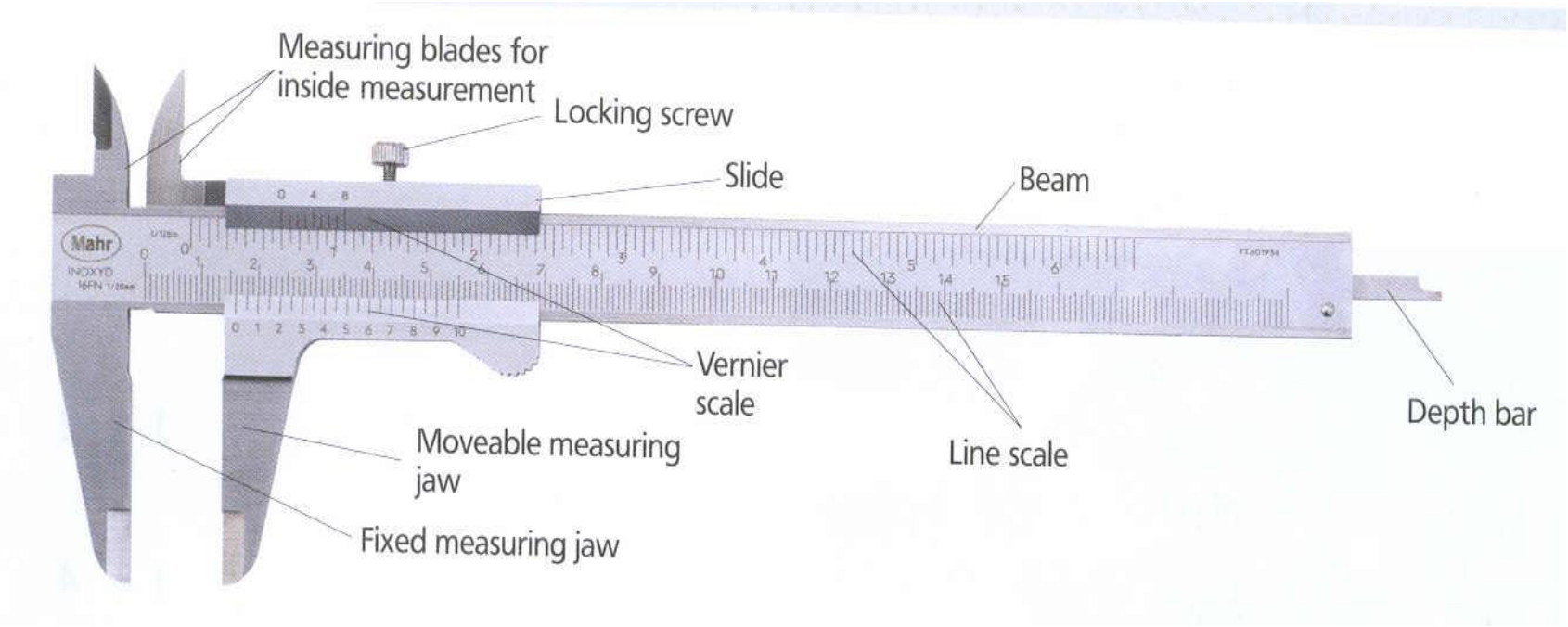


Vernier Calliper

- **Vernier Principle :** **When two scales (Main and Vernier scales) or divisions slightly different in size are used, the difference between them can be utilized to enhance the accuracy of measurement.**



Vernier Callipers - Analogue



The Vernier Caliper is an instrument for measuring outside diameters, bores, lengths and depths on components.

Least Count of Vernier Calliper

- It is the capability of an instrument to measure minimum distance accurately.

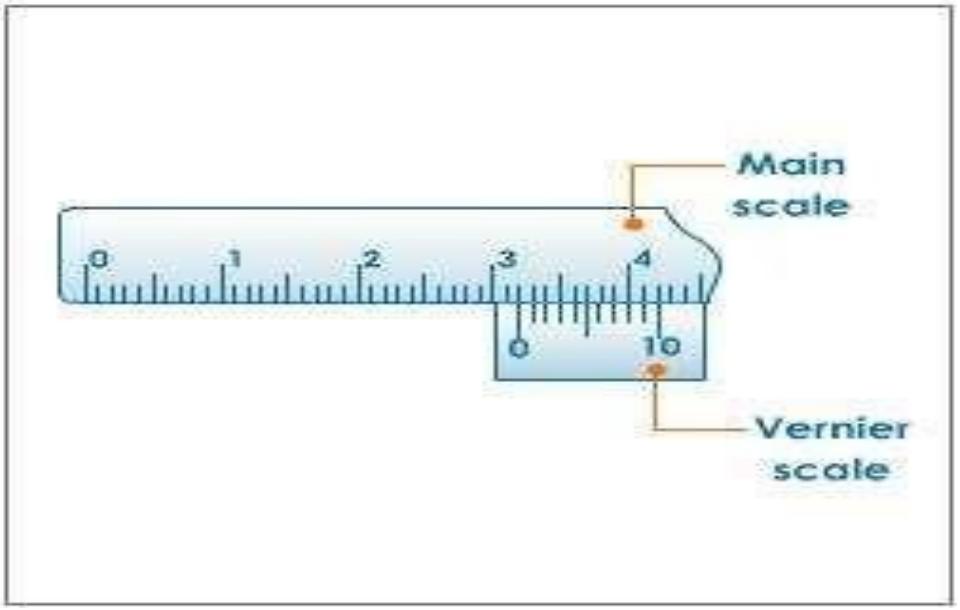
- The least count is the difference between the value of main scale division and vernier scale division.

Least Count (L.C.) of Vernier Calliper

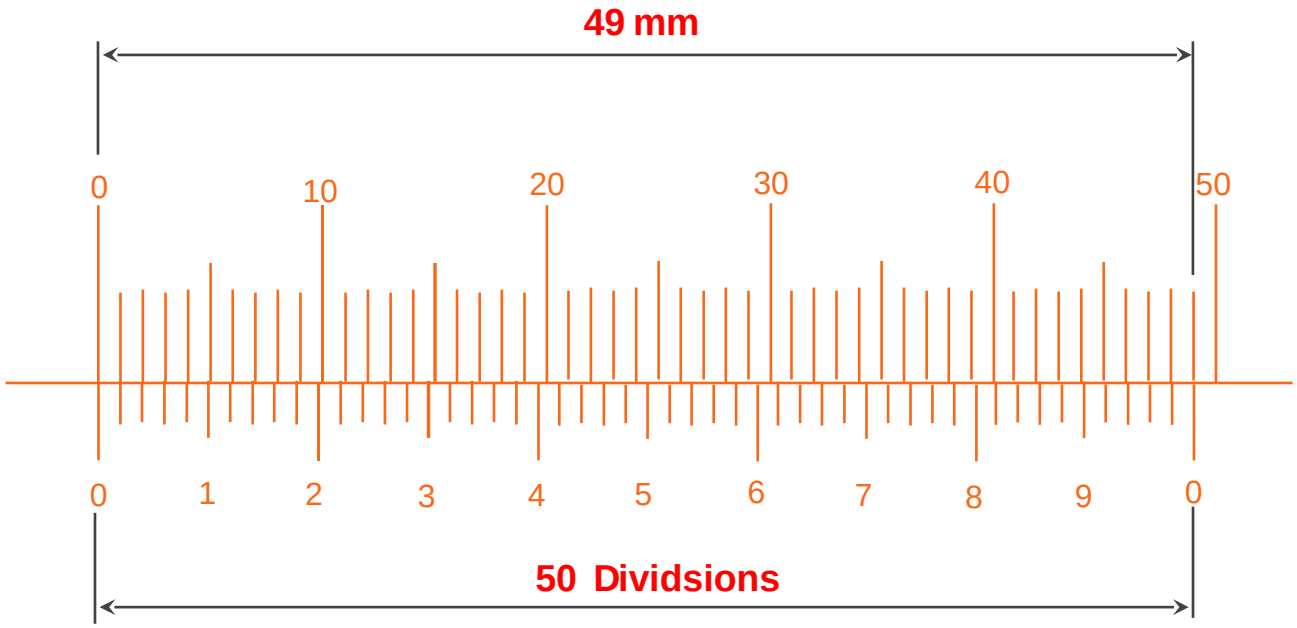
L.C. = Value of smallest division on Main Scale / no. of division on Vernier Scale

= 1 mm/10

= 0.1 mm = 0.01 cm



Vernier Calliper Least Count

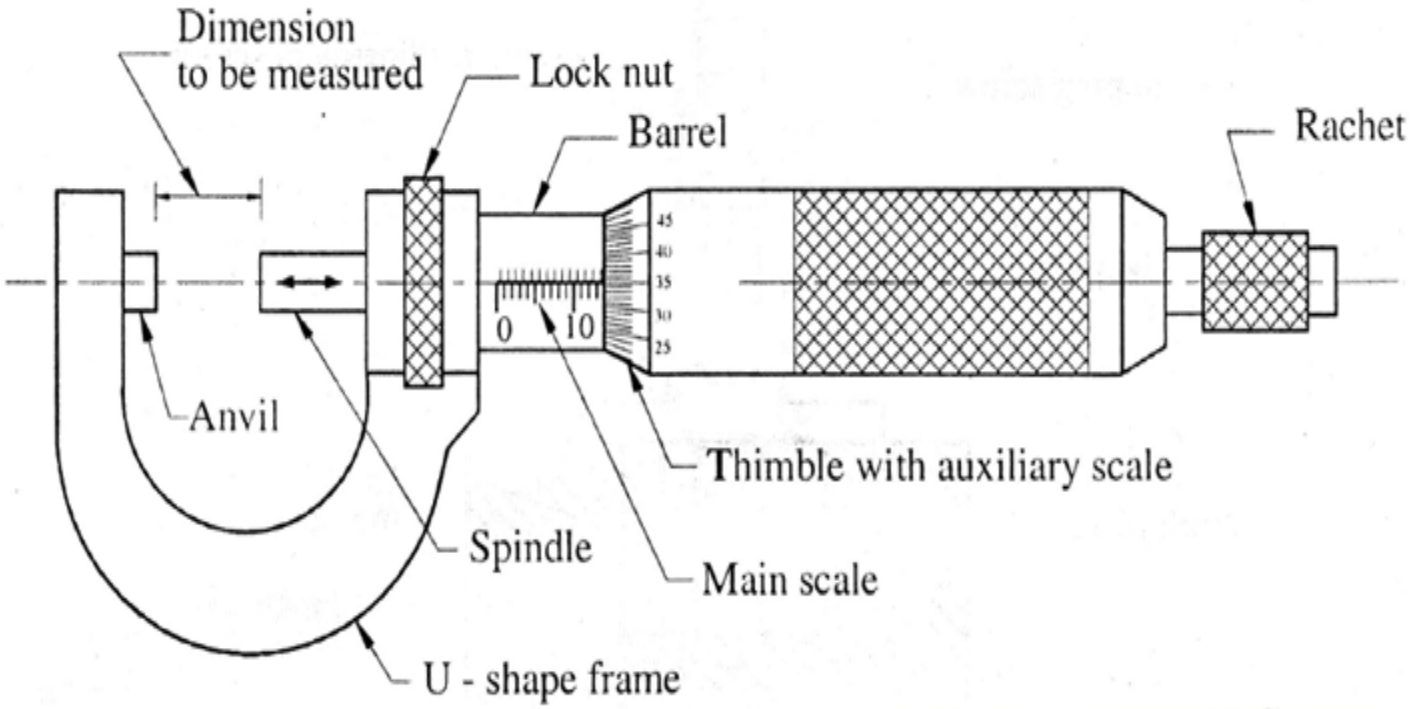


Least Count (L.C.) = 1 M.S.R. – 1 V. S.R. = $\frac{49}{50}$ mm = 1- 0.98 = 0.02

MICROMETERS

- Useful device for magnifying small measurement.
- Micrometers works on the principle of screw and nut. The screw is attached to thimble.
- A screw is turned through nut by one revolution, its axial movement is equal to pitch of the thread of screw.

Construction

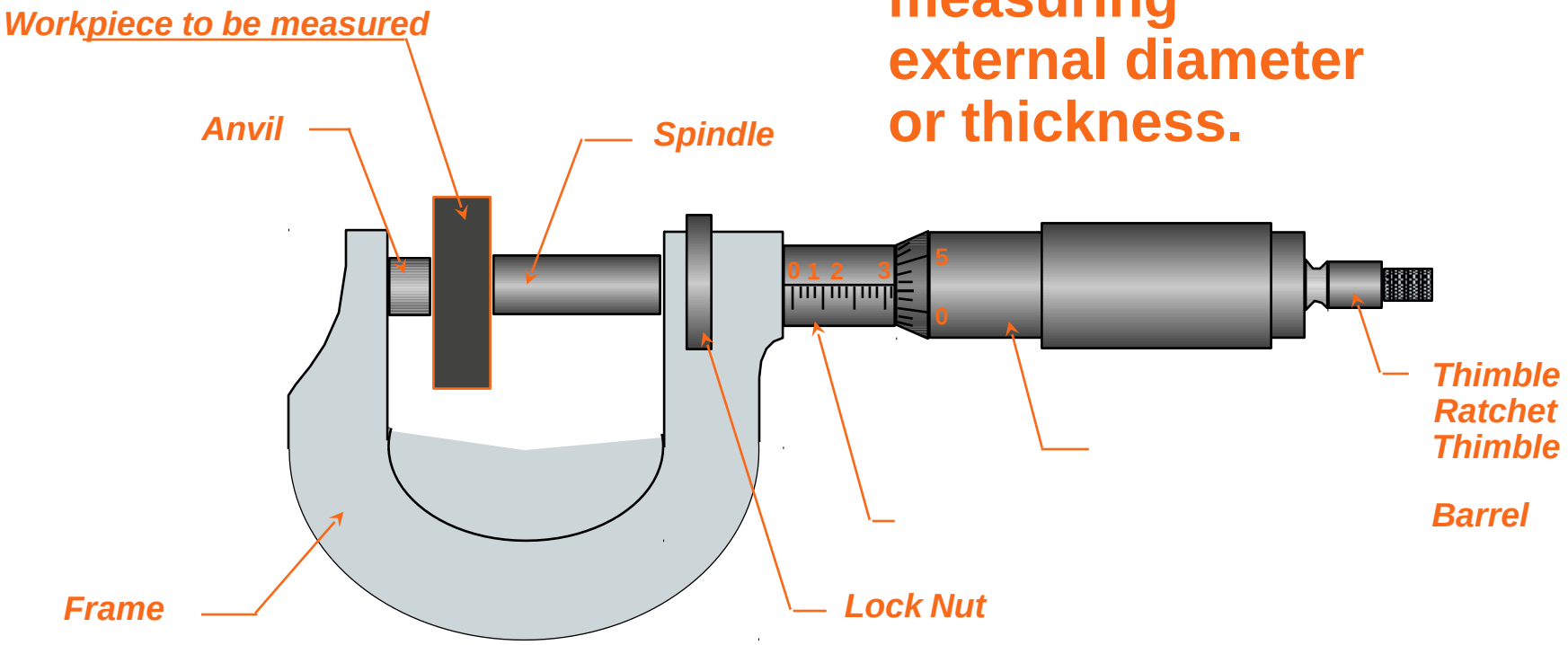


MICROMETERS

MICROMETER

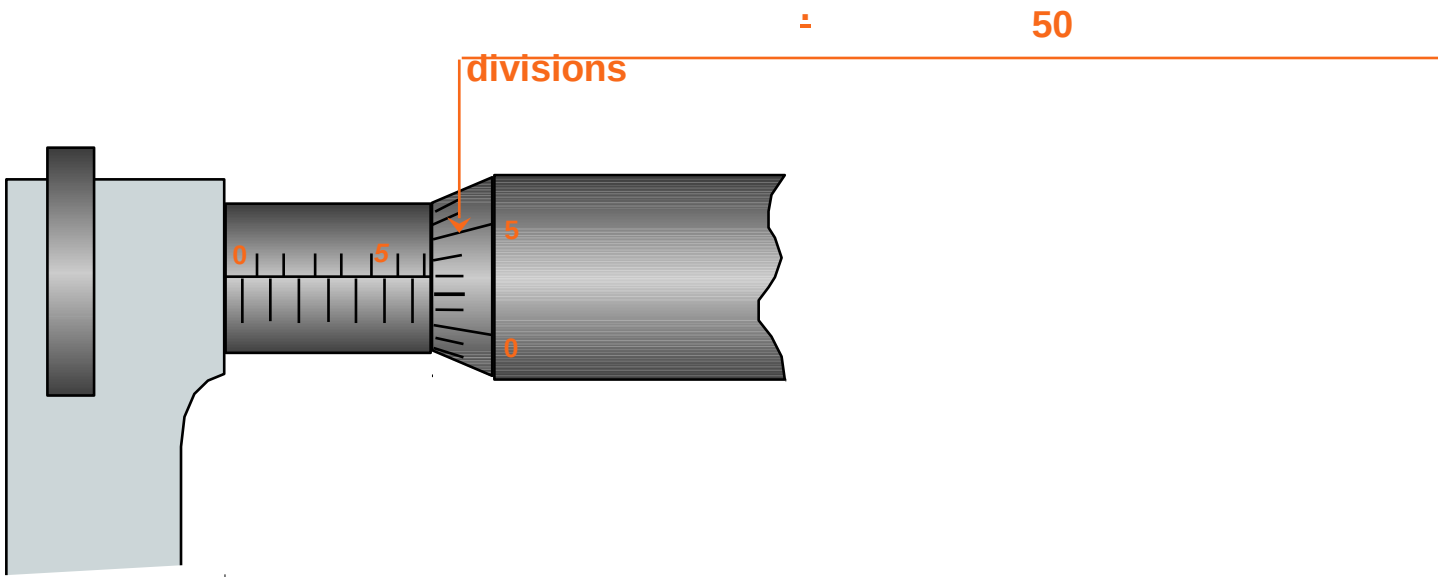
External Micrometer

- **used for measuring external diameter or thickness.**

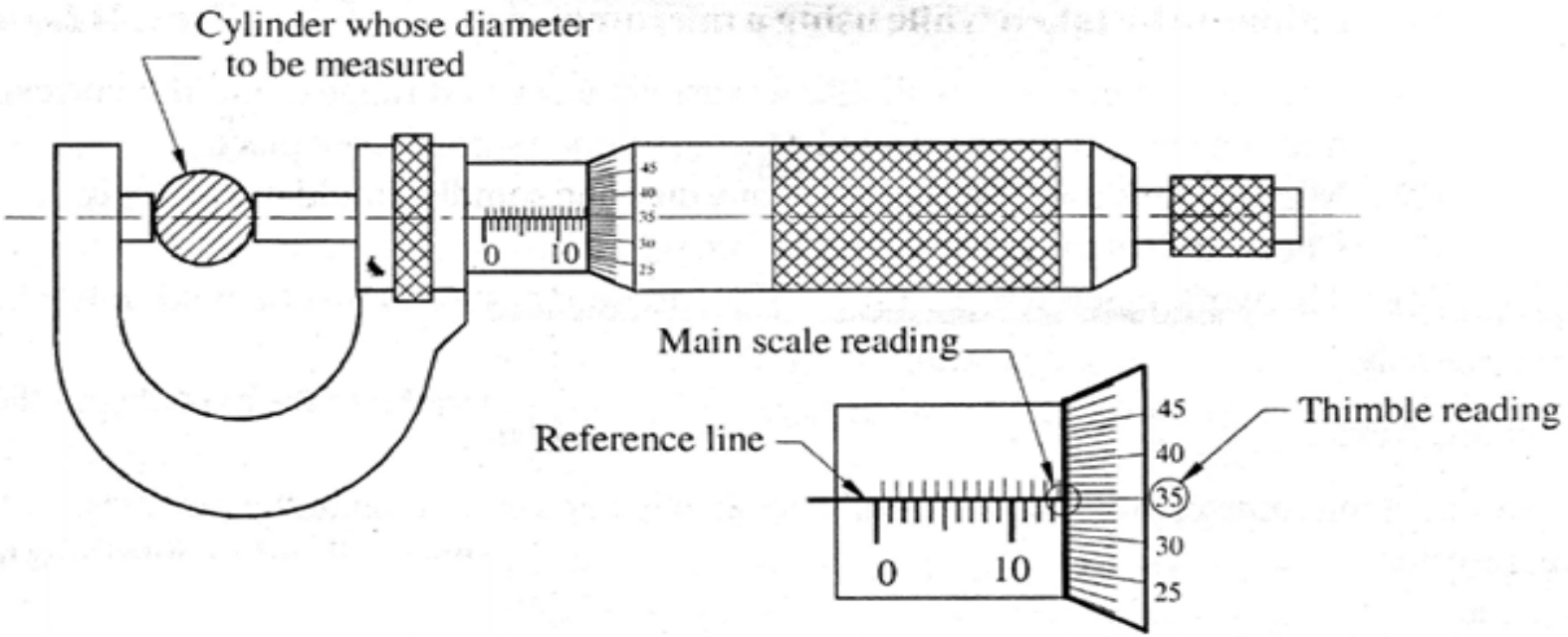


Least Count of a MICROMETER

Total divisions in the Circular Scale = 50 divisions
Linear movement in one rotation of Circular Scale (Pitch) = 0.5 mm
Least Count = 0.5/50 = 0.01 mm



Reading on a MICROMETER



Total reading = Main scale reading + (L.C. × reading on thimble)

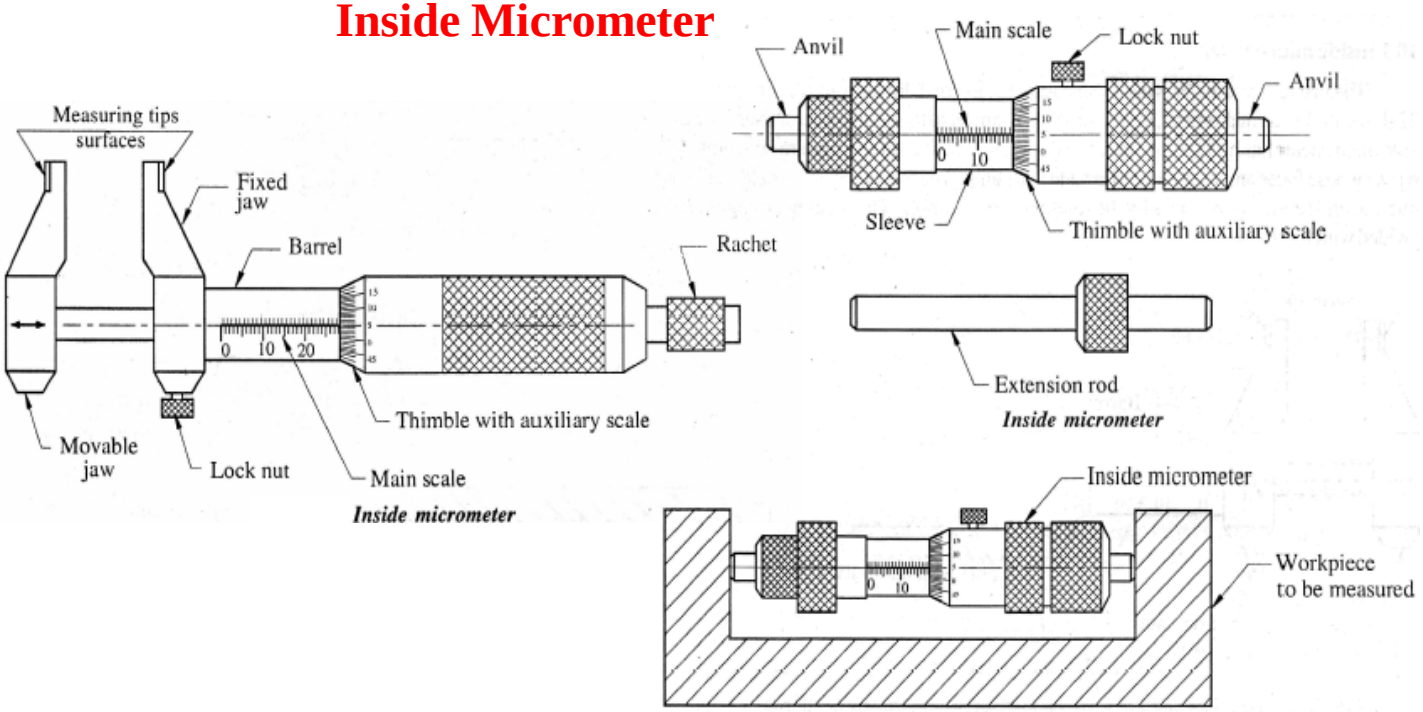
$$= 13.5 + 0.01 \times 35$$

$$\left(\because \text{L.C.} = \frac{\text{Value of smallest division on main scale or pitch}}{\text{No. of divisions on thimble}} \right.$$

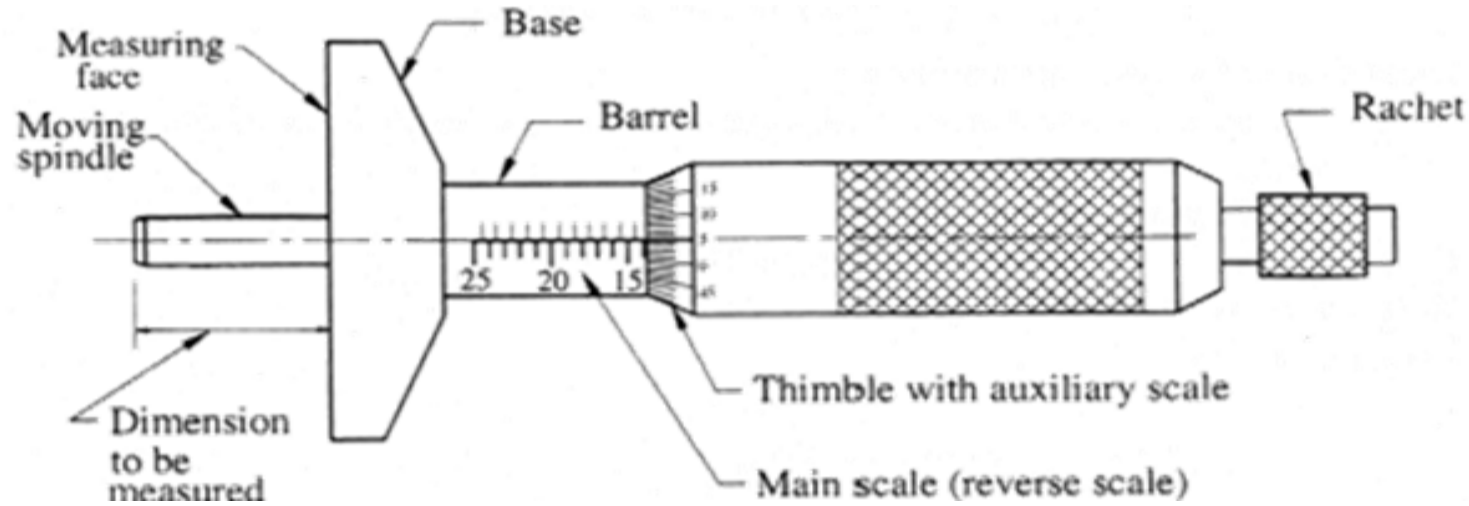
$$\left. = \frac{0.5}{50} = 0.01 \right)$$

$$= 13.85 \text{ mm}$$

Inside Micrometer



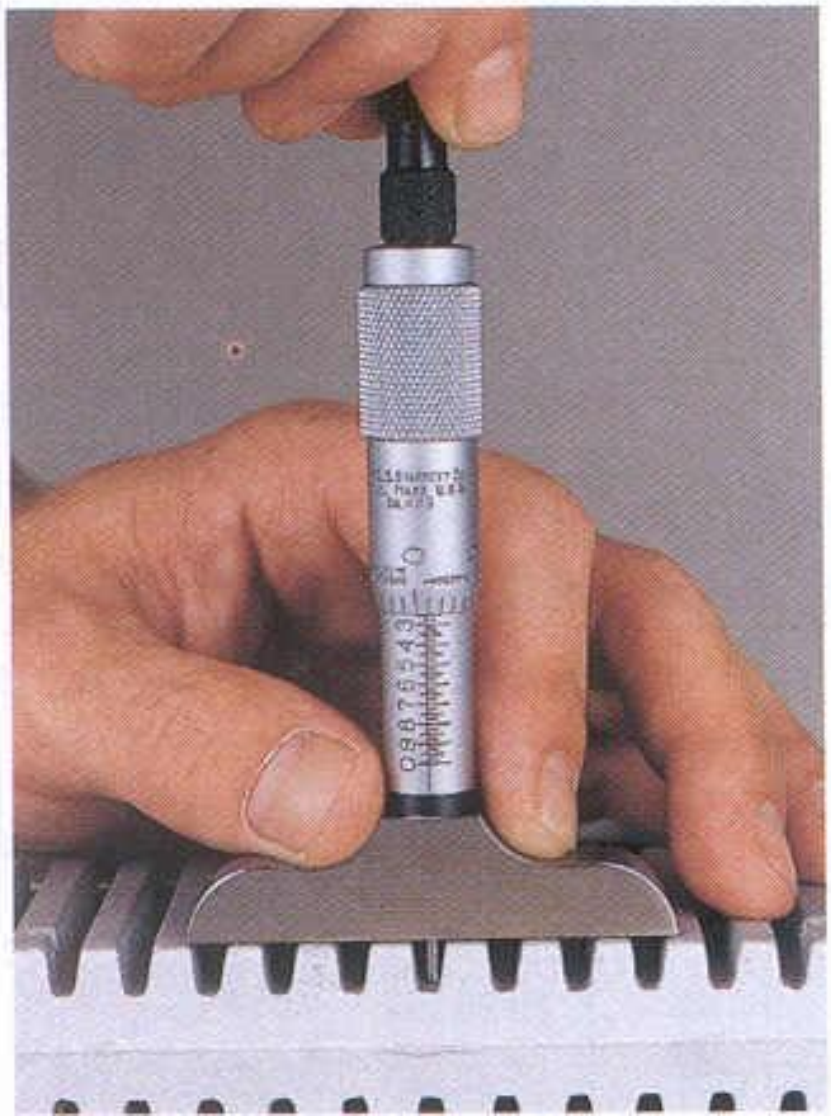
Depth Micrometer



DIGITAL MICROMETER

Micrometer with Dial Gauge

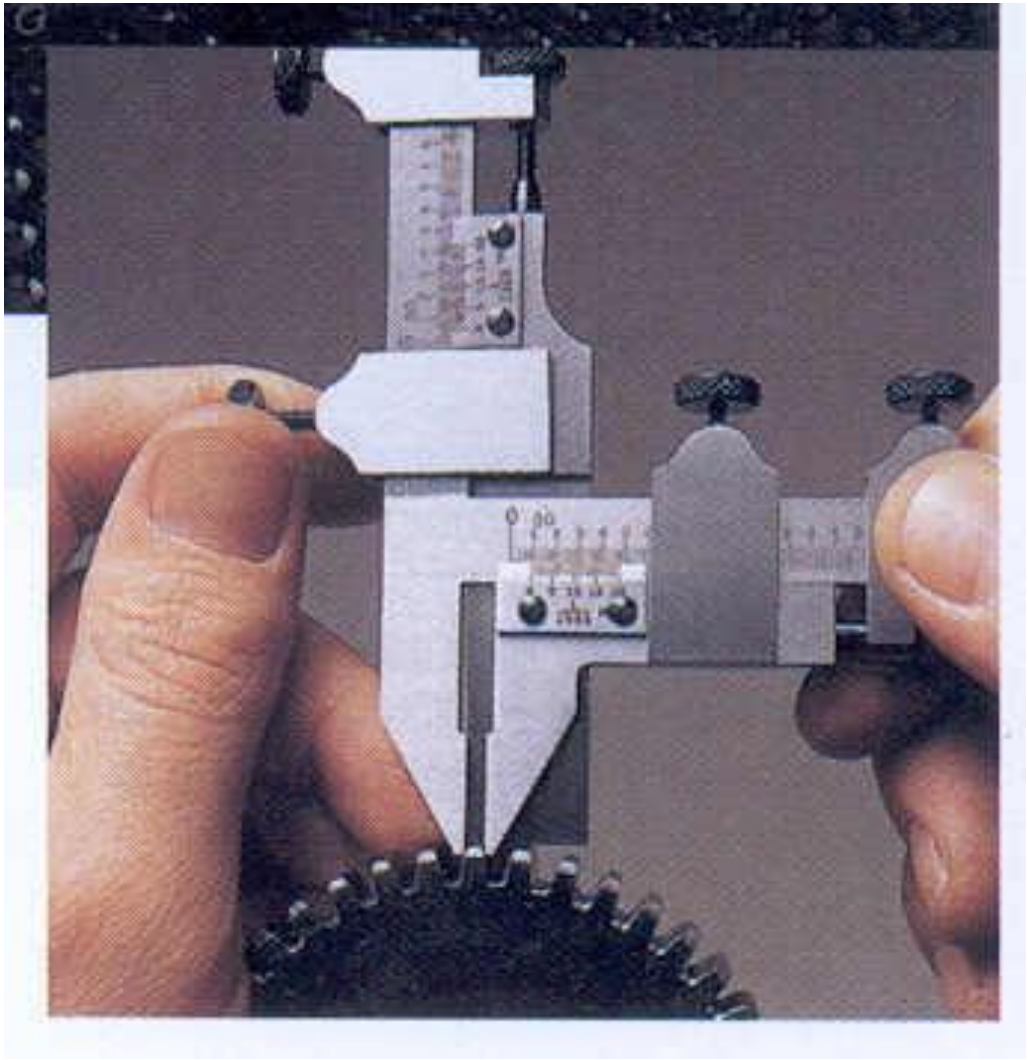
Depth Micrometers



Depth Micrometer

Used for measuring depths of holes and shoulders accurately

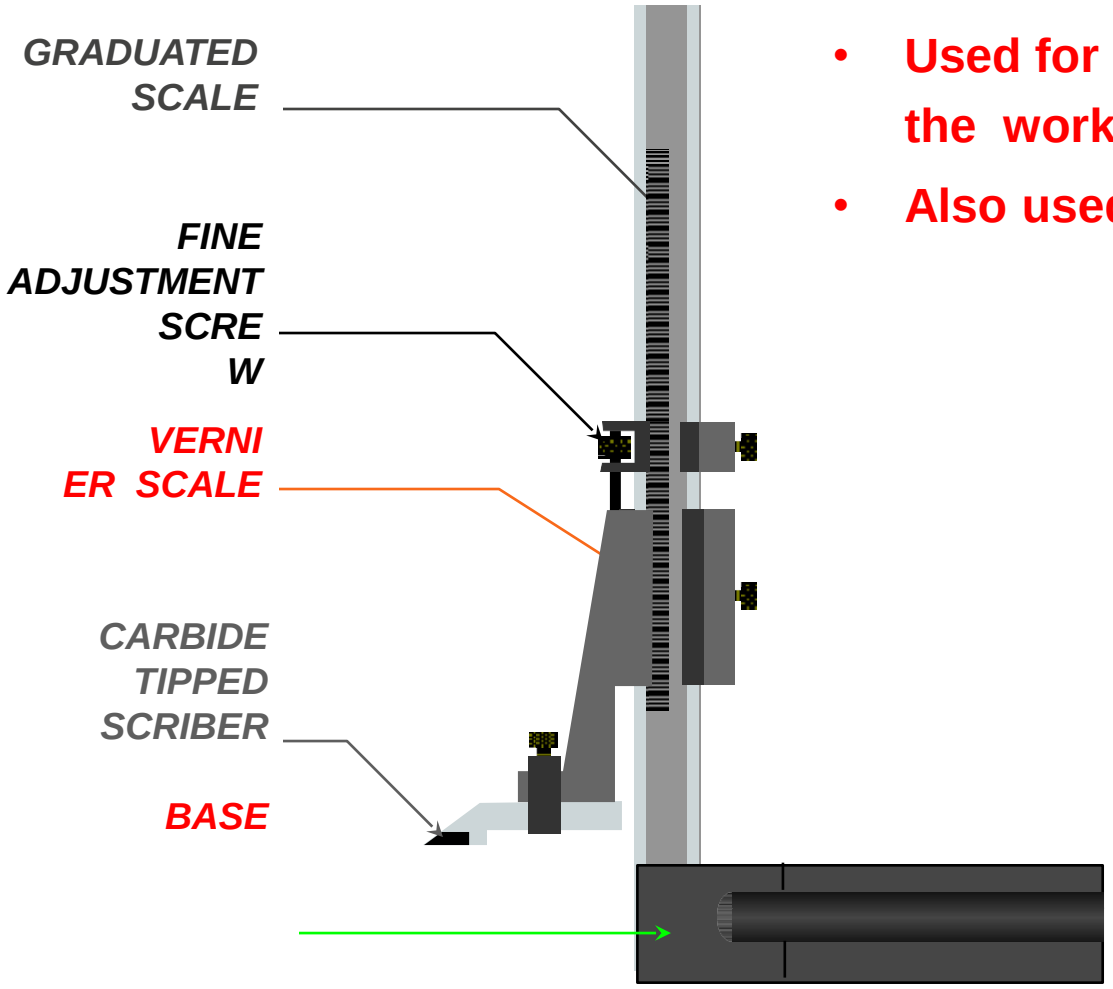
Linear Measurements – Gear Tooth Vernier



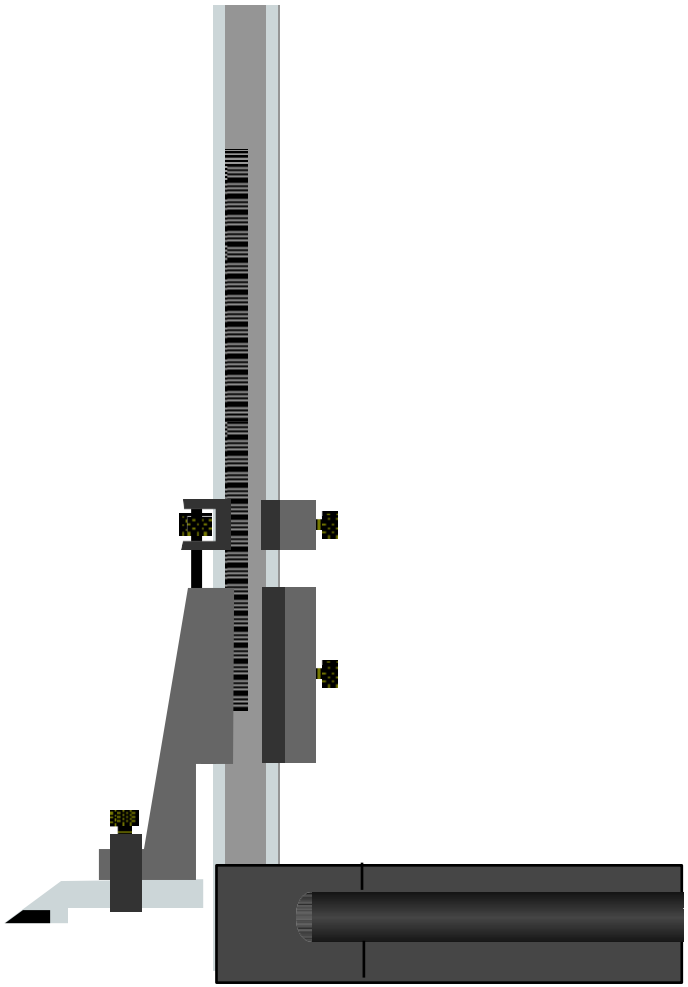
Gear Tooth Vernier Similar to two Verniers used at 90°. Used for measuring chordal tooth thickness of gear teeth

VERNIER HEIGHT GAUGE

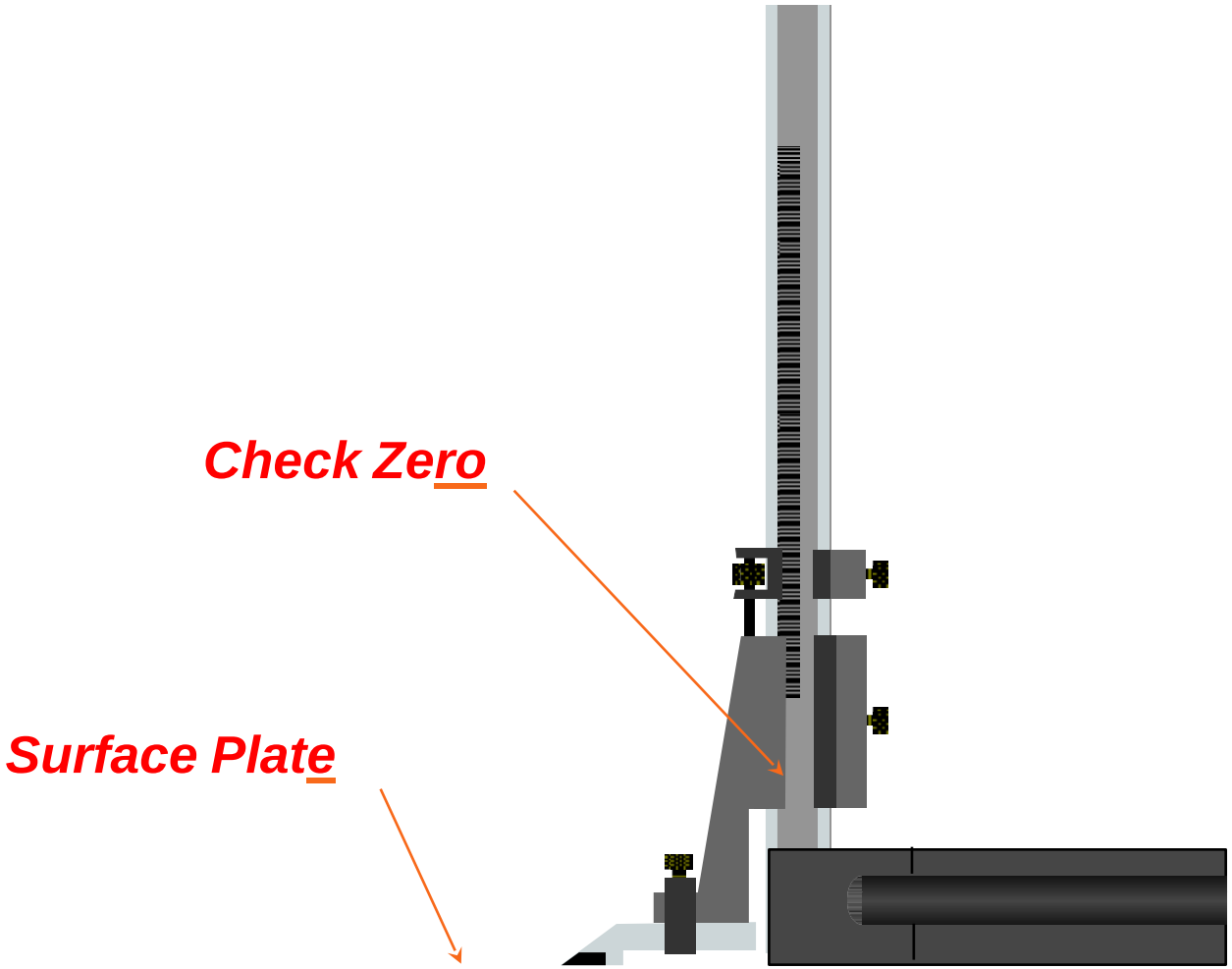
- Used in connection with a surface table.
- Fitted with a carbide tips.
- Used for marking the lines on the workpiece.
- Also used for taking height



VERNIER HEIGHT GAUGE

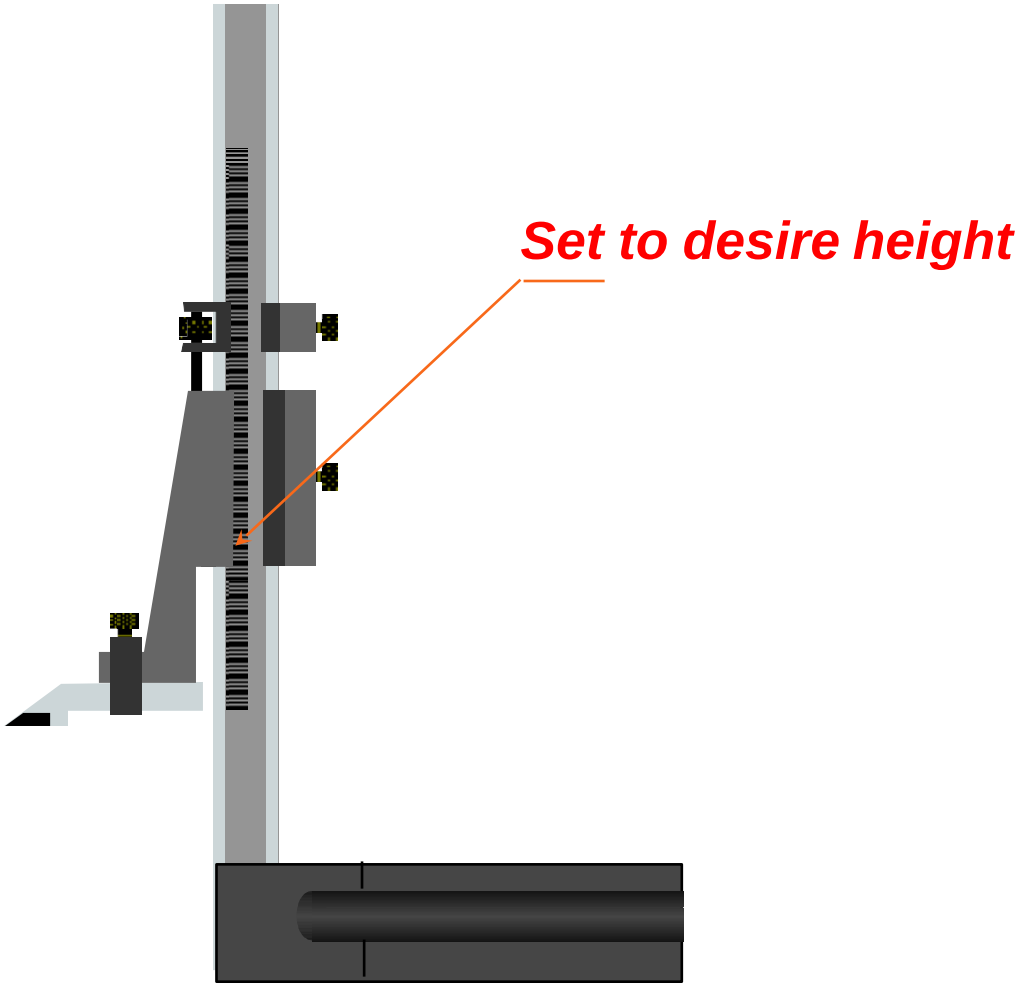


VERNIER HEIGHT GAUGE

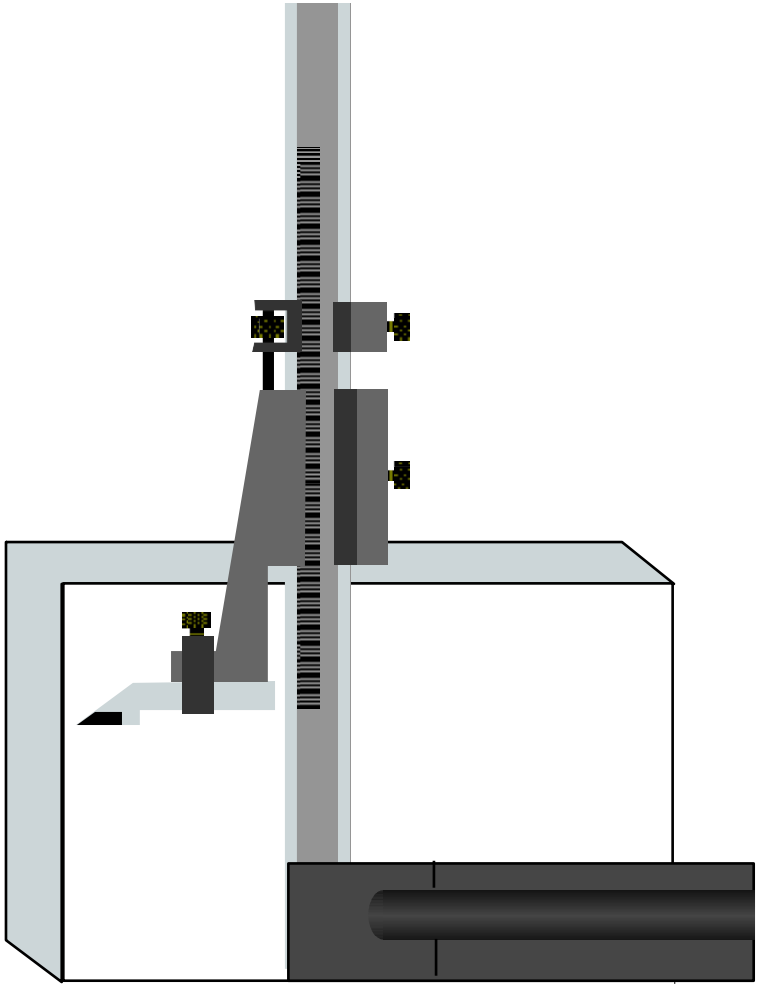


VERNIER HEIGHT GAUGE

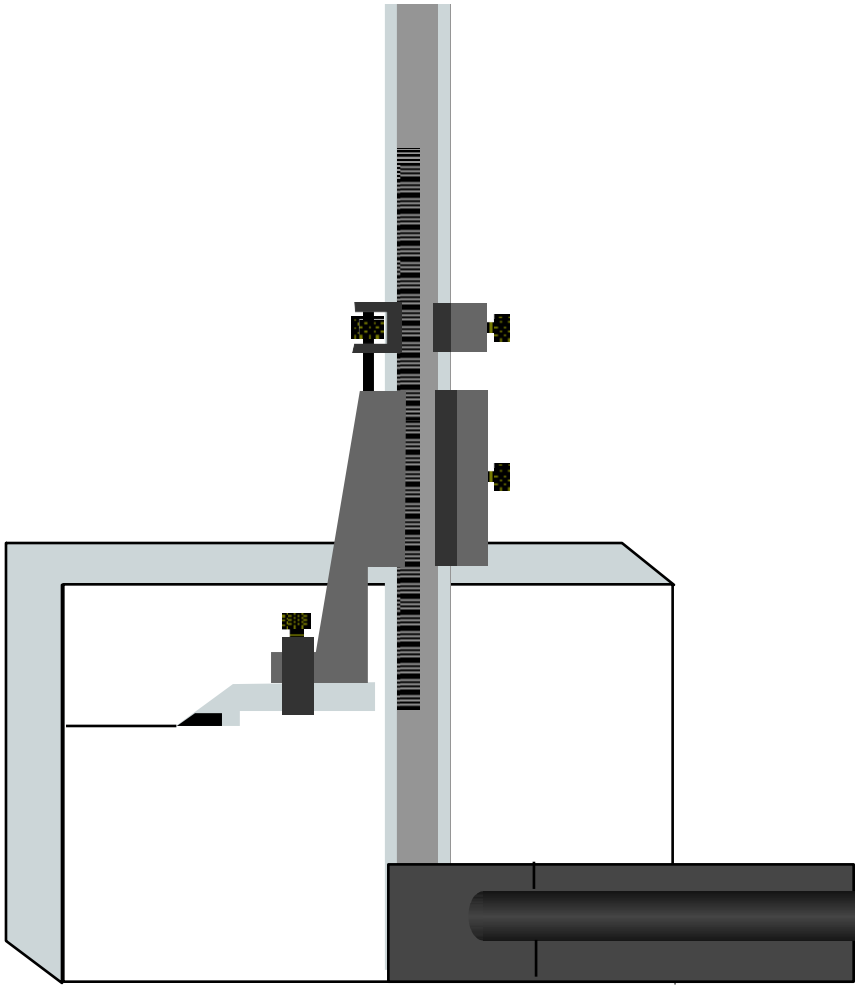
As a Marking tools



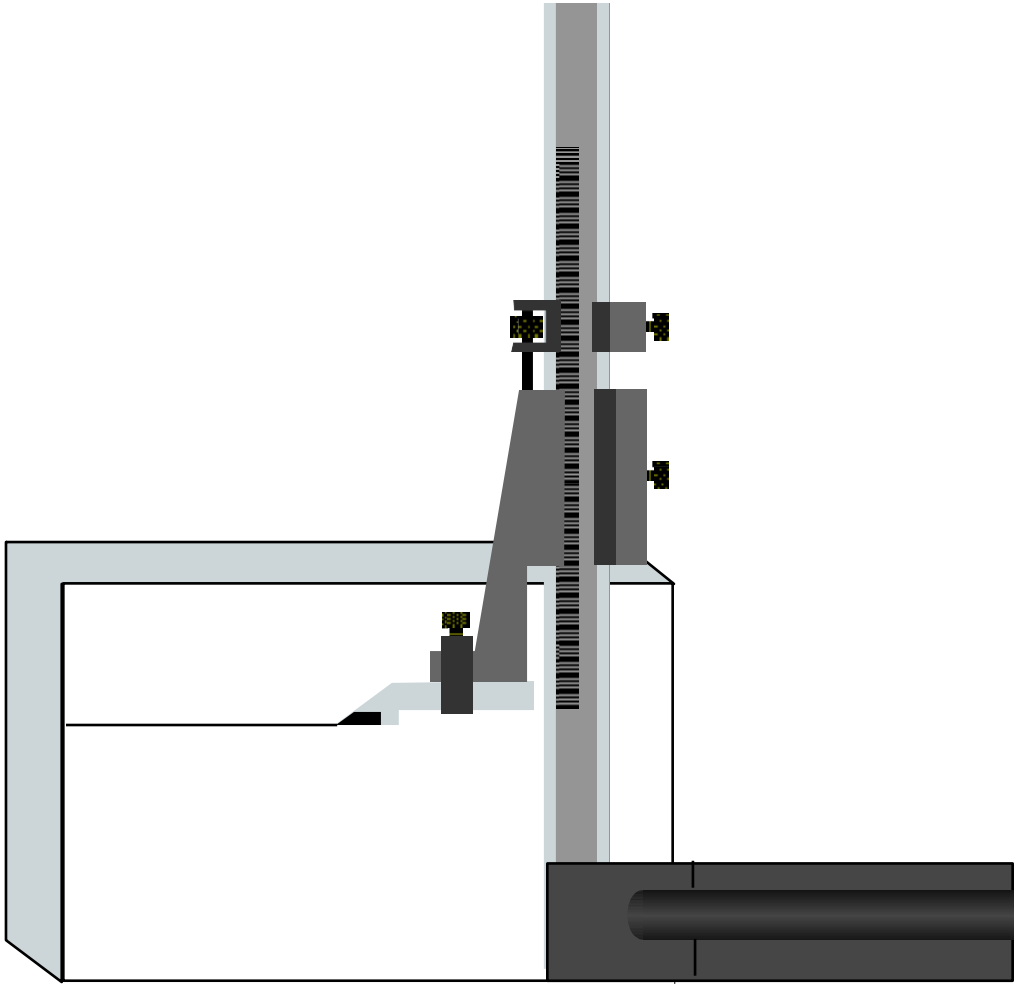
VERNIER HEIGHT GAUGE



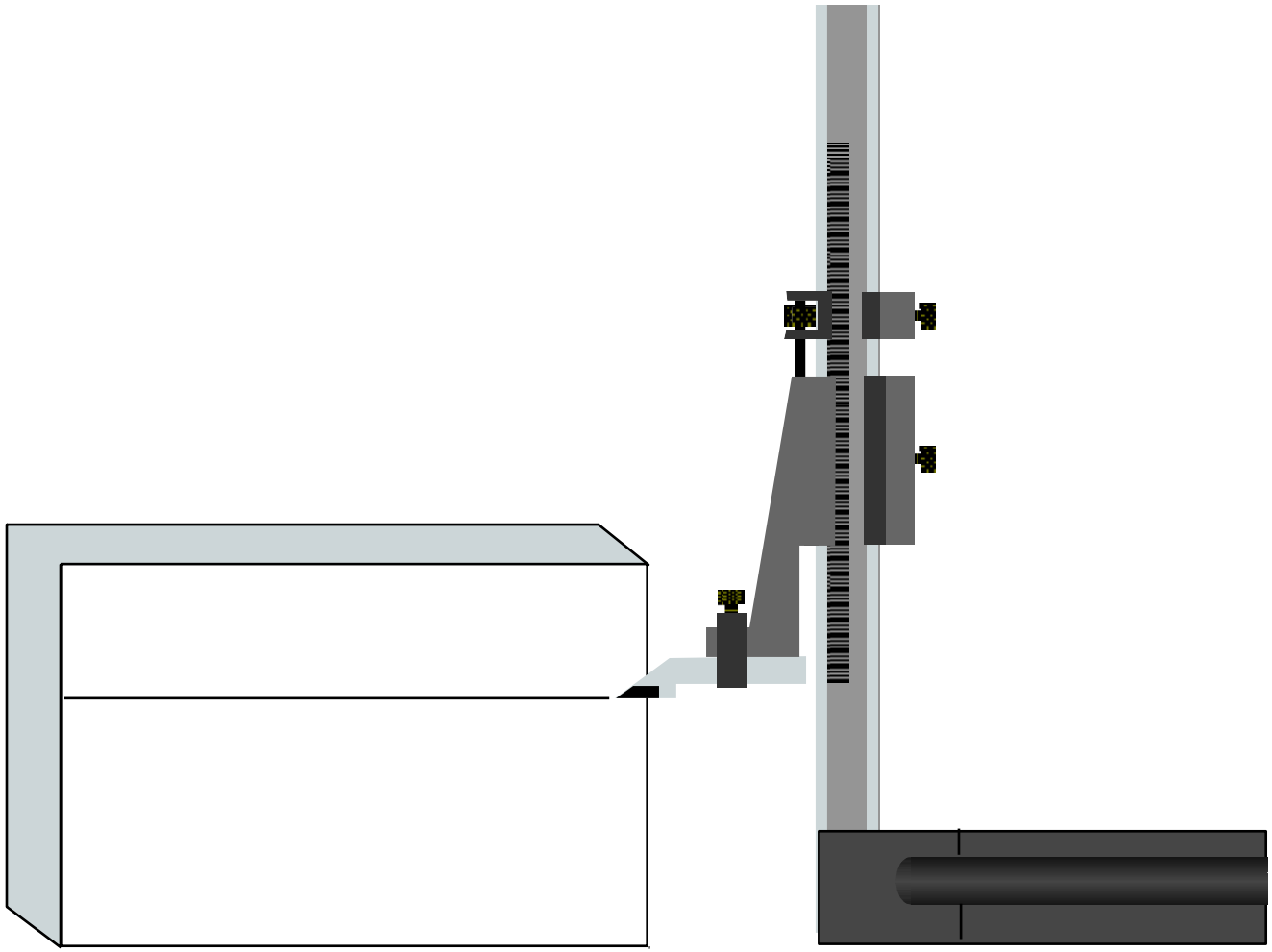
VERNIER HEIGHT GAUGE



VERNIER HEIGHT GAUGE

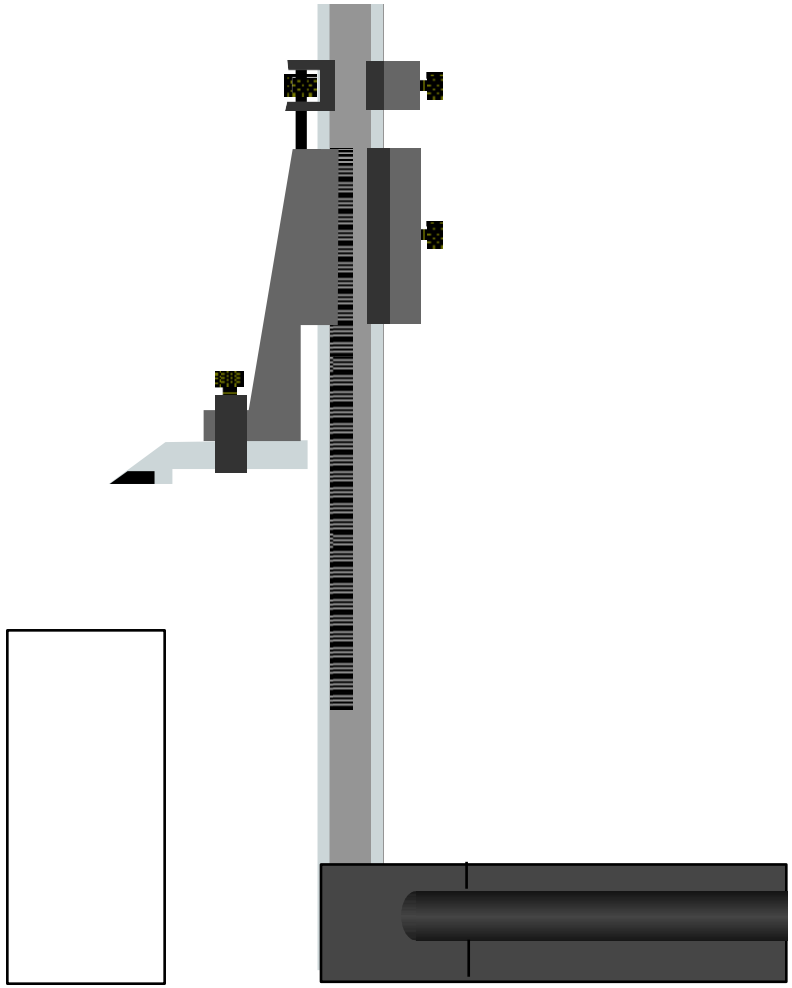


VERINER HEIGHT GAUGE

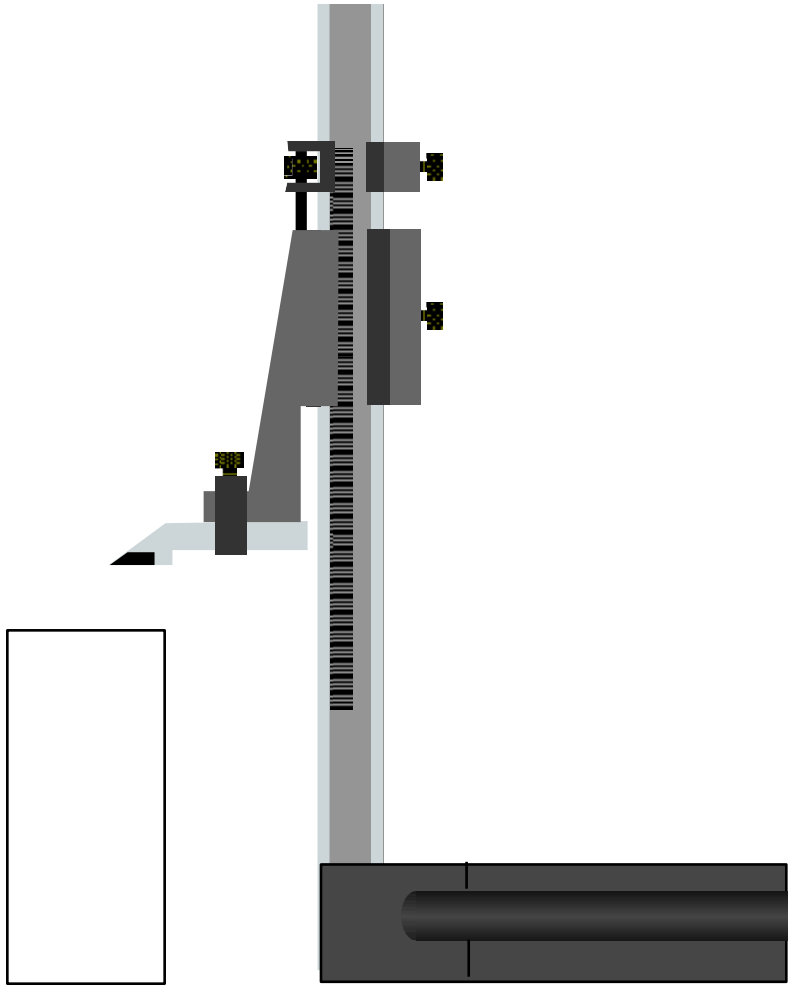


VERNIER HEIGHT GAUGE

As a measuring tools



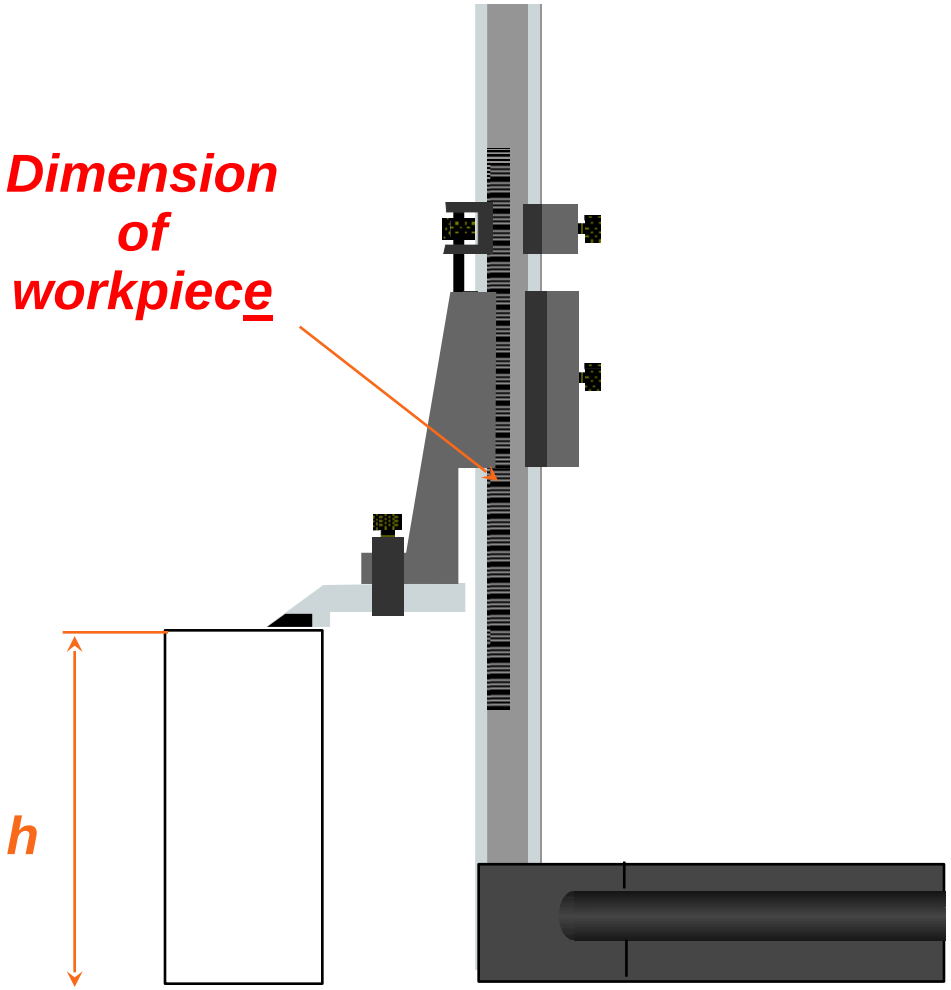
VERNIER HEIGHT GAUGE



VERNIER HEIGHT GAUGE

Finding out the height of workpiece

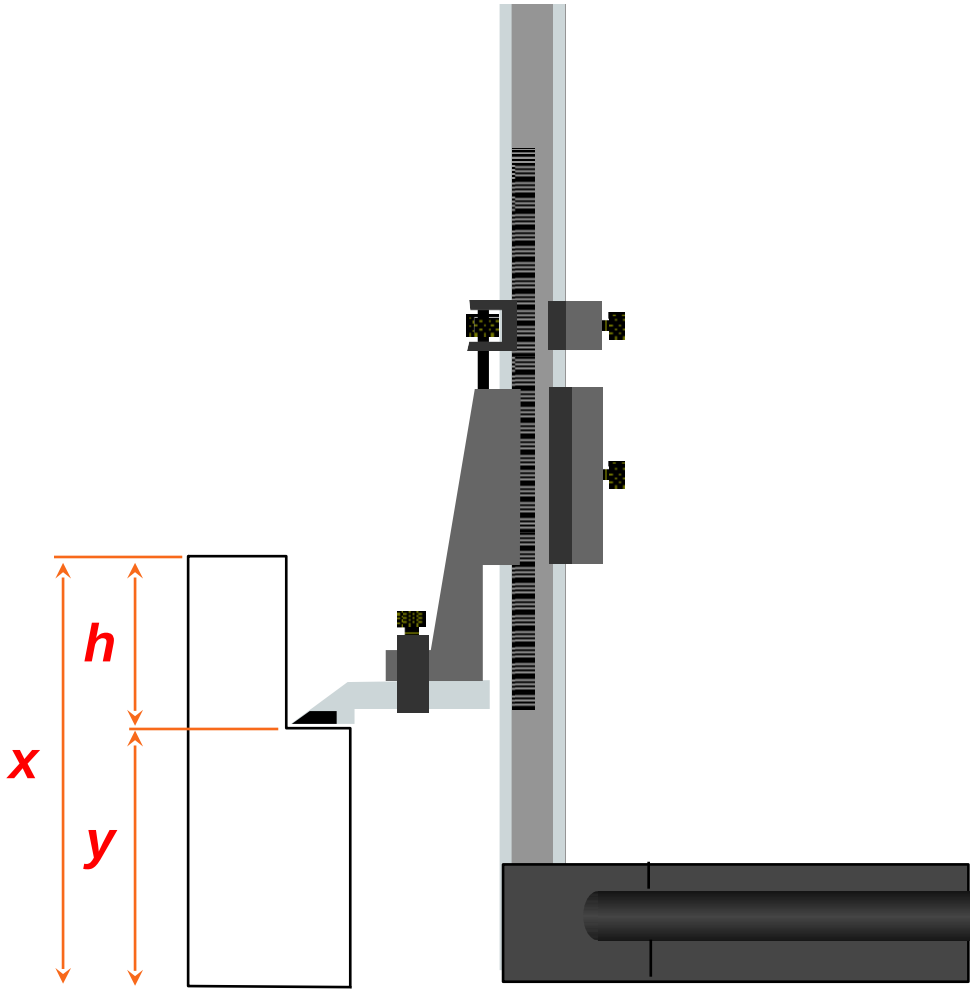
Dimension of workpiece



VERNIER HEIGHT GAUGE

Finding out the height of step

$h = x - y$



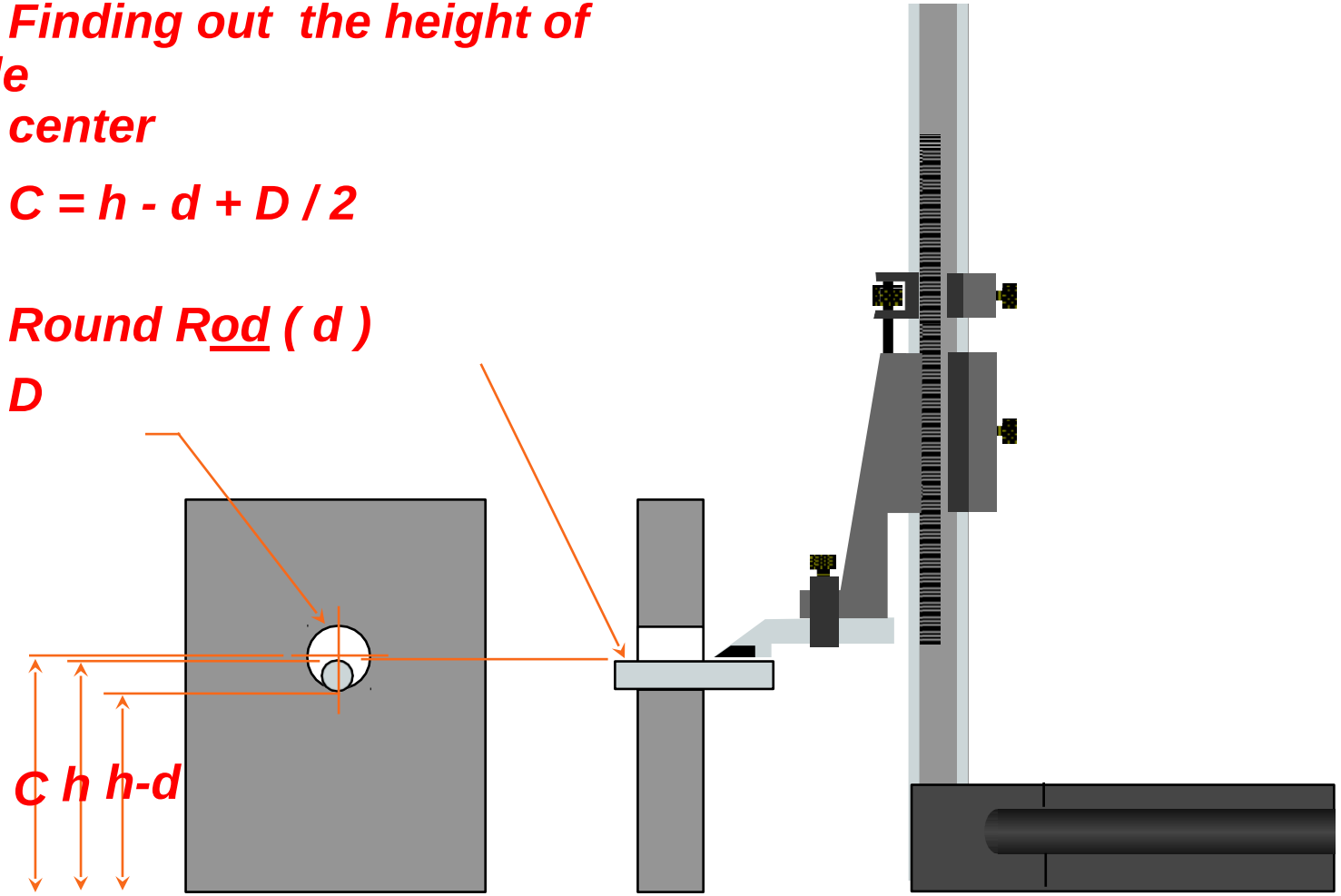
VERNIER HEIGHT GAUGE

Finding out the height of hole center

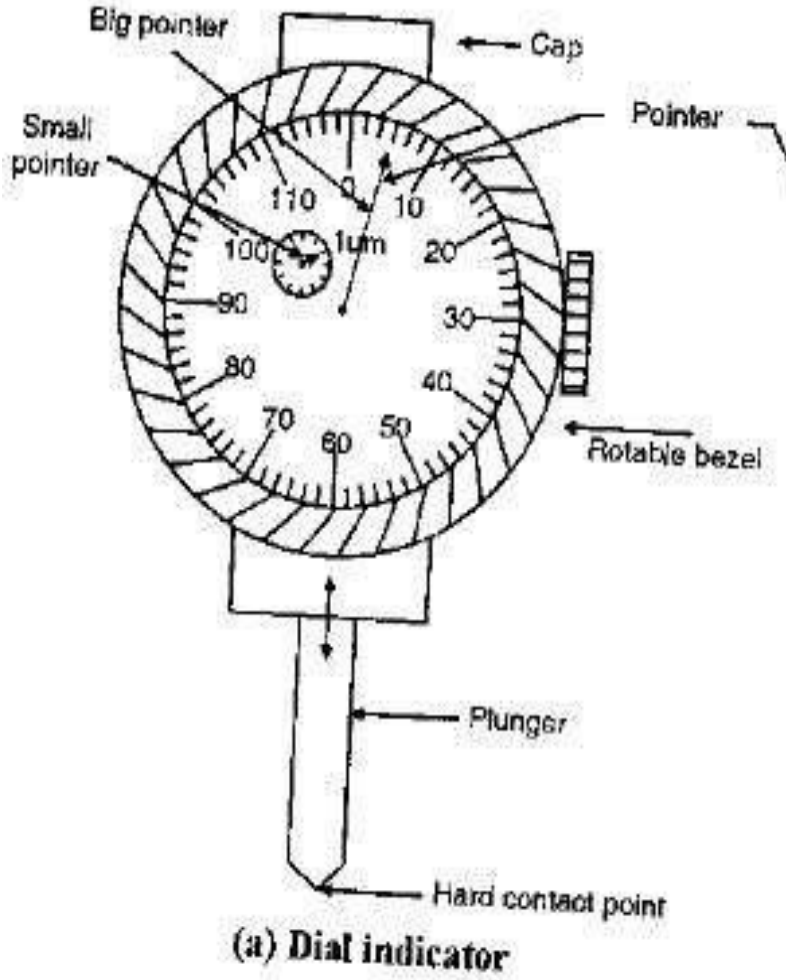
$$C = h - d + D / 2$$

Round Rod (d)

D



DIAL INDICATOR

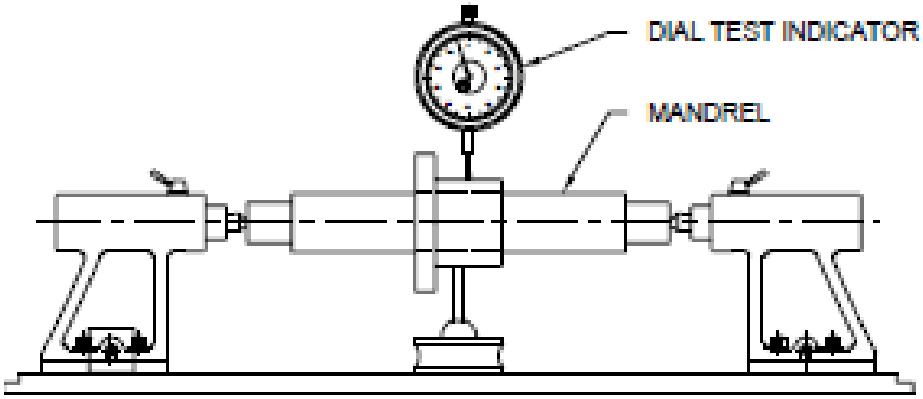


(a) Dial indicator

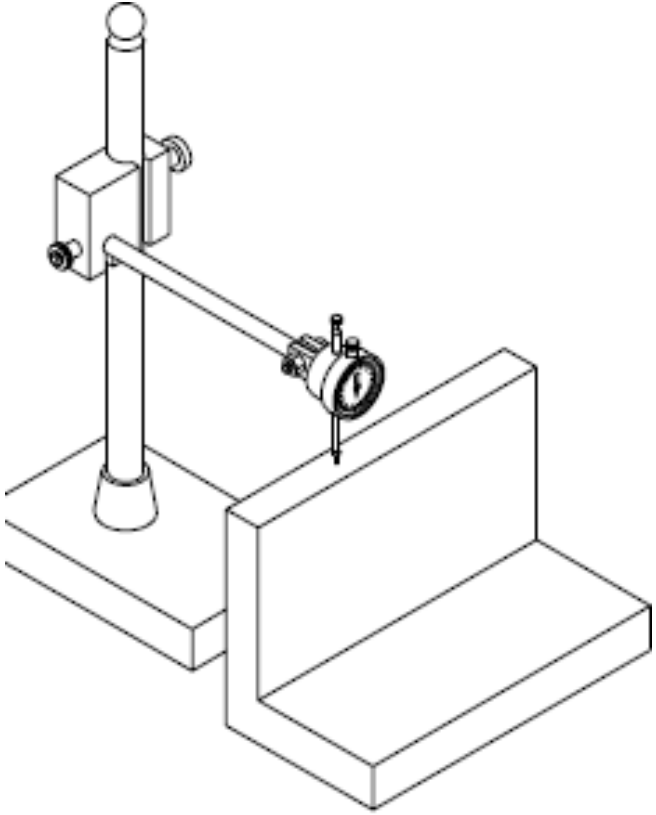
Dial Indicator with Stand

Checking the alignment of Lathe Centers

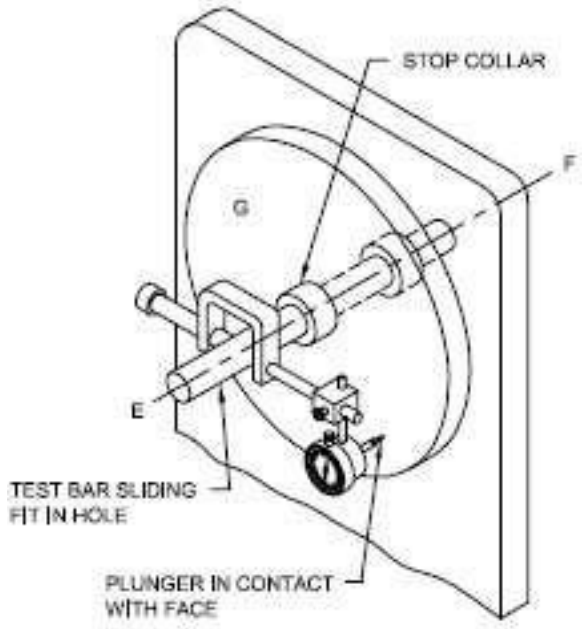
Checking of Dia of Shaft



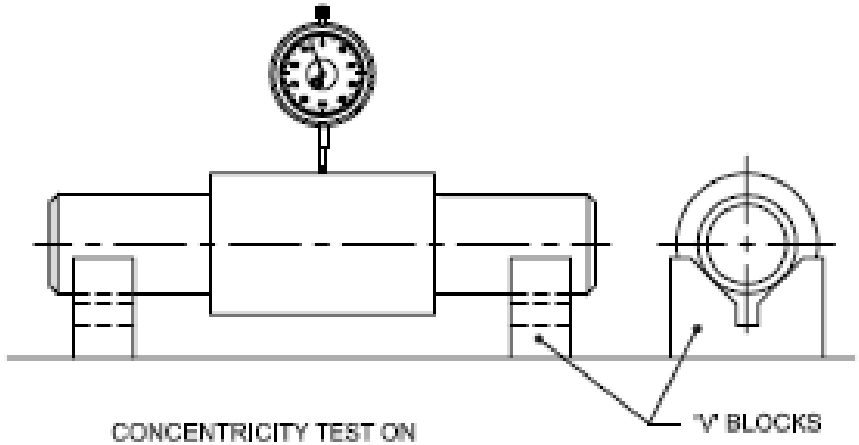
(B) TESTING BUSH FOR CONCENTRICITY



CHECKING FOR PARALLELISM



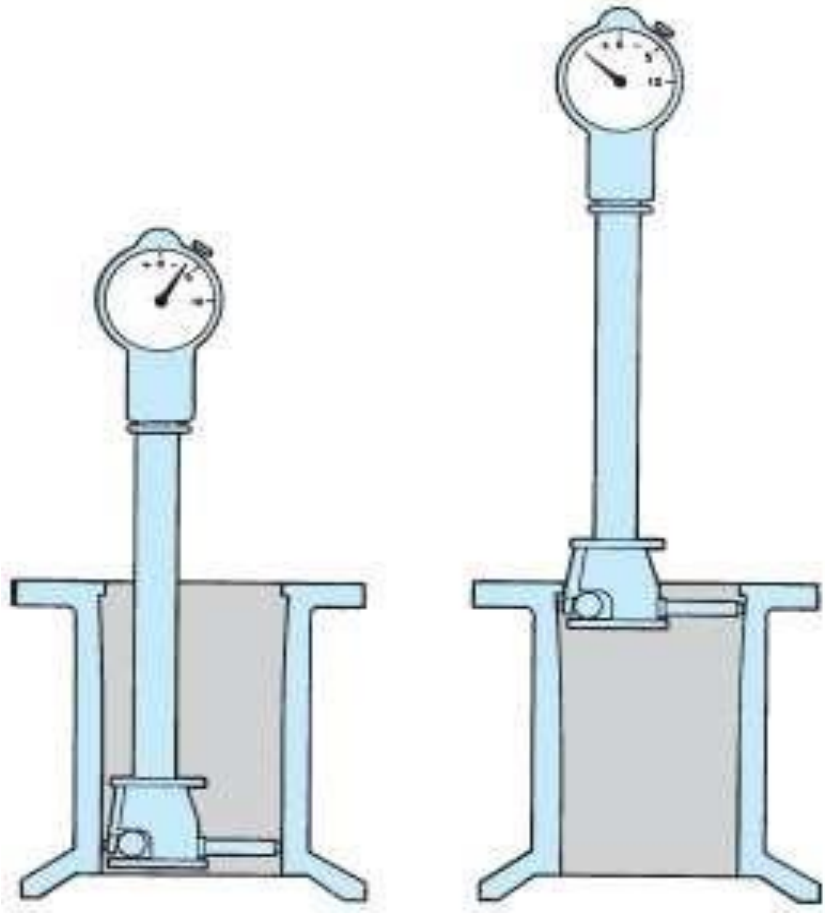
TESTING SQUARENESS OF FACE G WITH AXIS EF OF CENTRE HOLE



CONCENTRICITY TEST ON ENLARGED PORTION OF SHAFT

Dial Bore Gauge

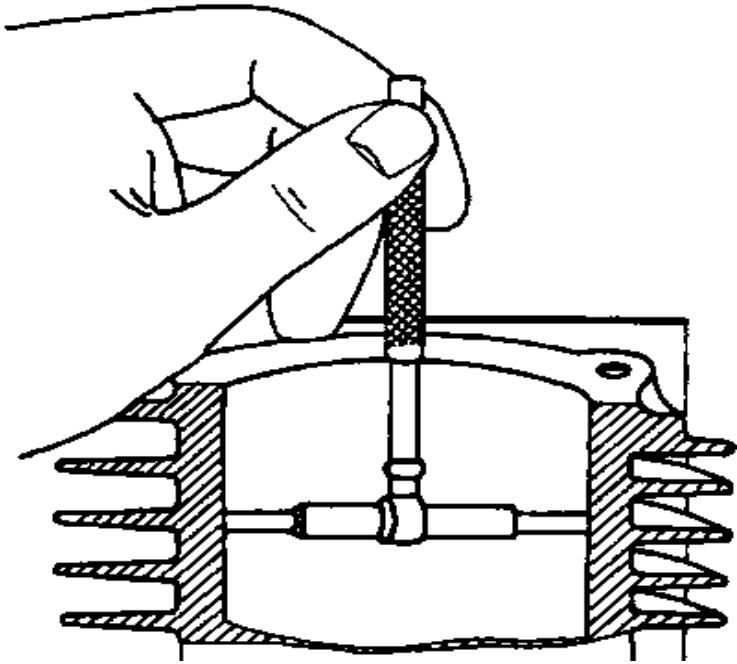
A Dial Bore Gauge is used to measure cylinder taper and out-of-round as well as main bearing (block housing) bore for taper and out-of-round



Dial Bore Gauge

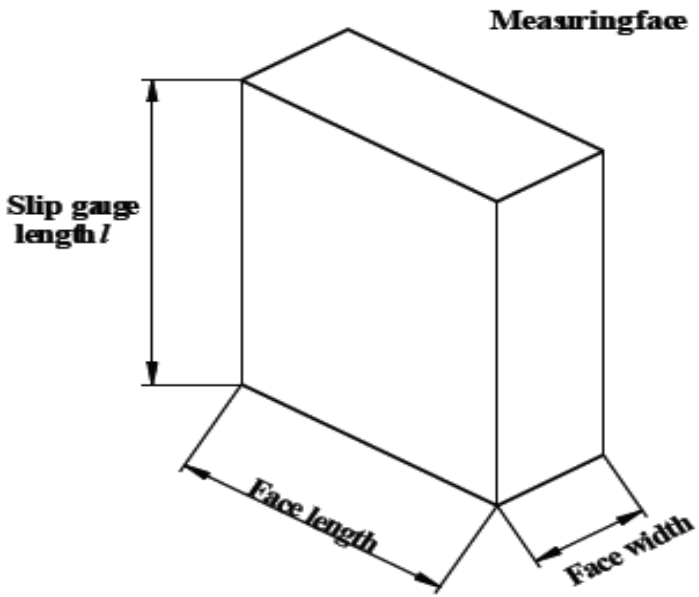

IKEA

Telescopic Gauges



SLIP GAUGE/GAUGE BLOCKS – Slip Gauges are known as Gauge Blocks. They are Precise Measuring Instruments. These Slip Gauges are universally accepted end Standard of length.

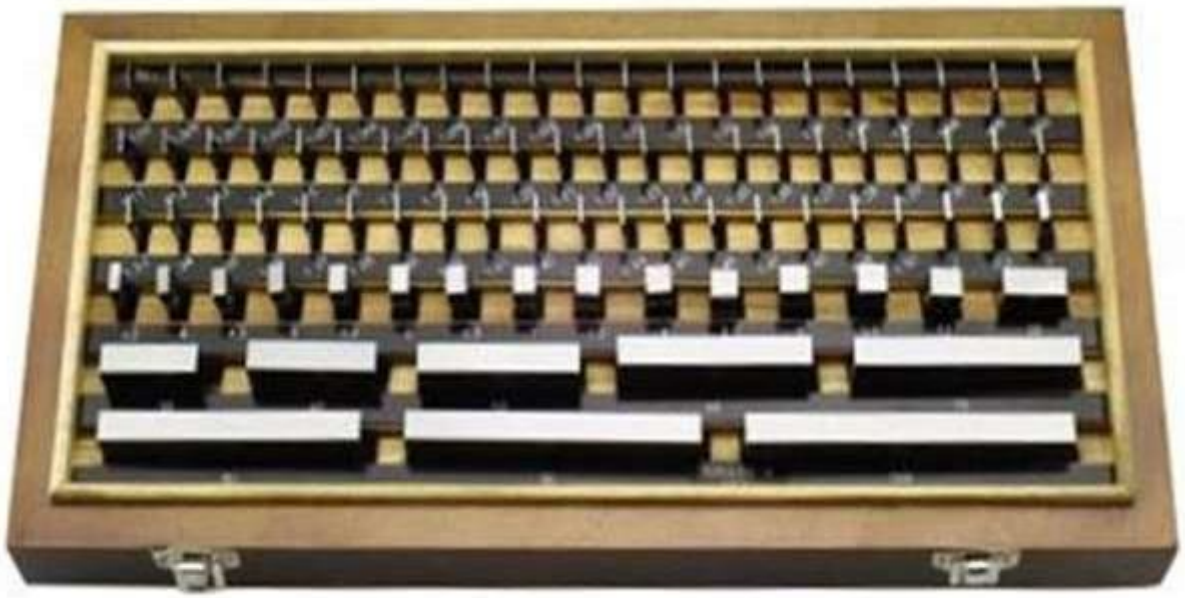
Slip Gauges



- **Slip Gauges** are blocks of steel that have been hardened and stabilized by heat treatment.
- They are ground and lapped to size to very high standards of accuracy and surface finish.
- A Gauge Block (also known Johansson Gauge, Slip Gauge, or Jo Block) is a precision length measuring standard.

Classification
(International Standard)

- **AA Slip Gauges**
- **A Slip Gauges**
- **B Slip Gauges**



- **AA SLIP GAUGES**
  - Master slip gauges
  - Accurate to plus or minus two microns per meter
- **A SLIP GAUGES**
  - Reference purpose
  - Type A is guaranteed accurate up to plus or minus four microns per meter
- **B SLIP GAUGES**
  - Working slip gauges
  - Type 'B' for plus or minus eight microns per meter

INDIAN STANDARD ON SLIP GAUGES (IS 2984-1966)

- **Slip Gauges are graded according to their accuracy as:**
  - **Grade 0**
  - **Grade I**
  - **Grade II**
- **Grade II is intended for use in workshops during actual production of components, tools & gauges.**
- **Grade I is of higher accuracy for use in inspection departments.**
- **Grade 0 is used in laboratories and standard rooms for periodic calibration of Grade I & Grade II gauges.**

SET OF SLIP GAUGES

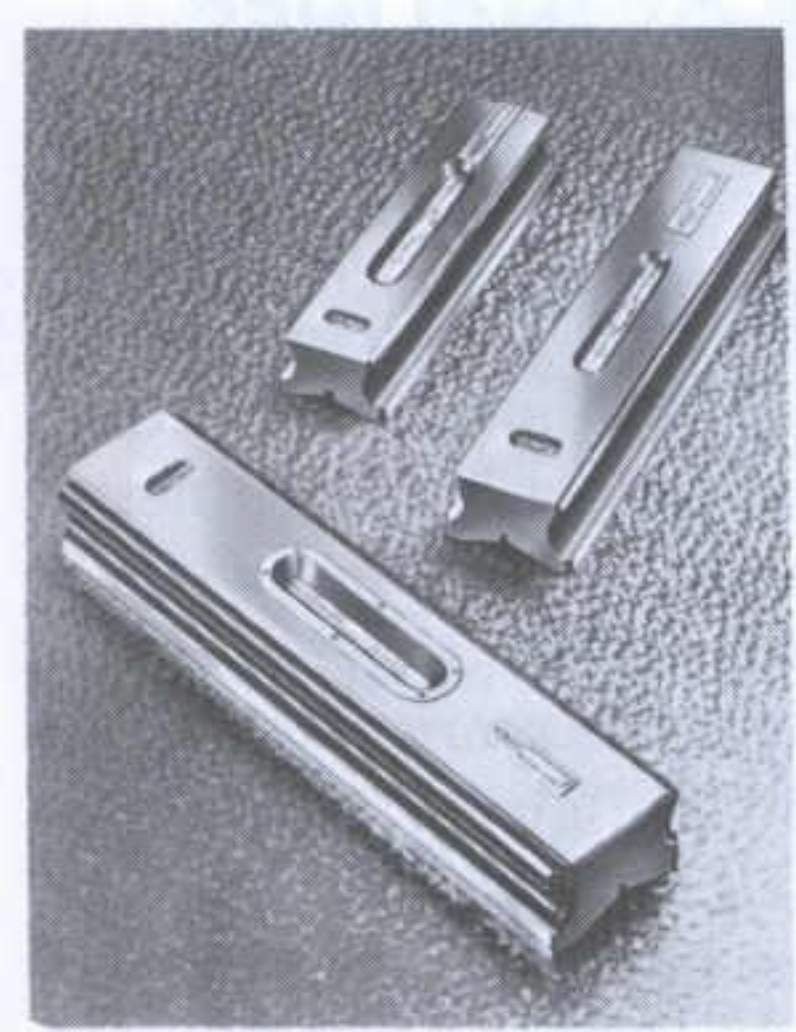
M-87 set of Slip Gauges

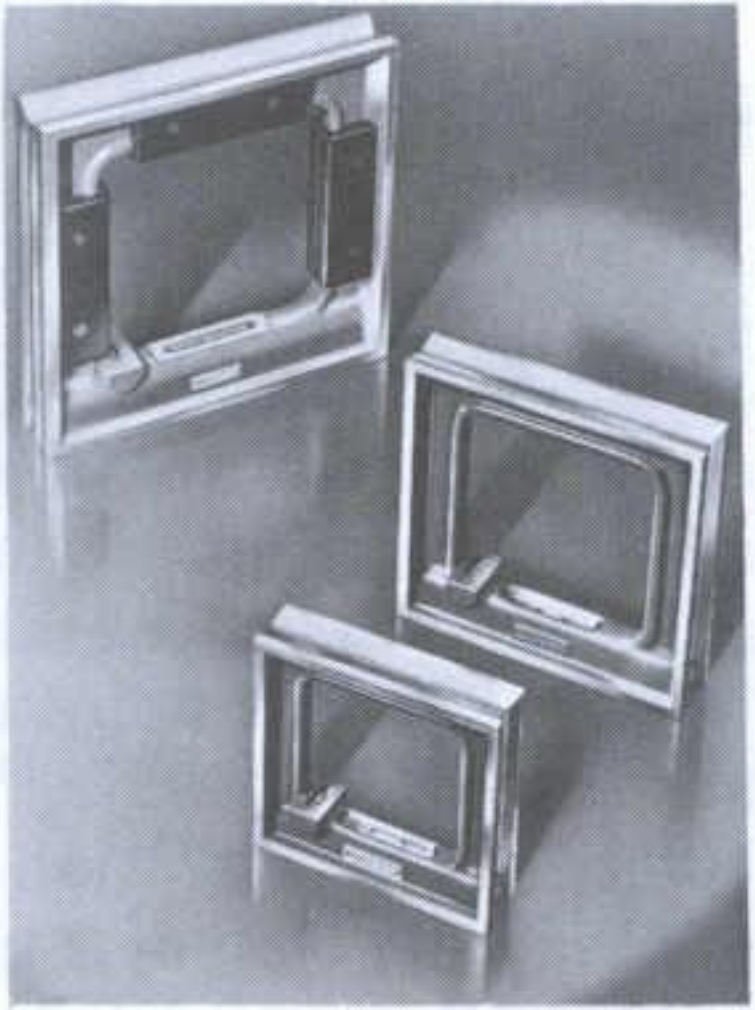
Range (mm)	Steps (mm)	No. of pieces
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10 to 90	10	9
1.0005	---	1
	Total	87

M-112 set of Slip Gauges

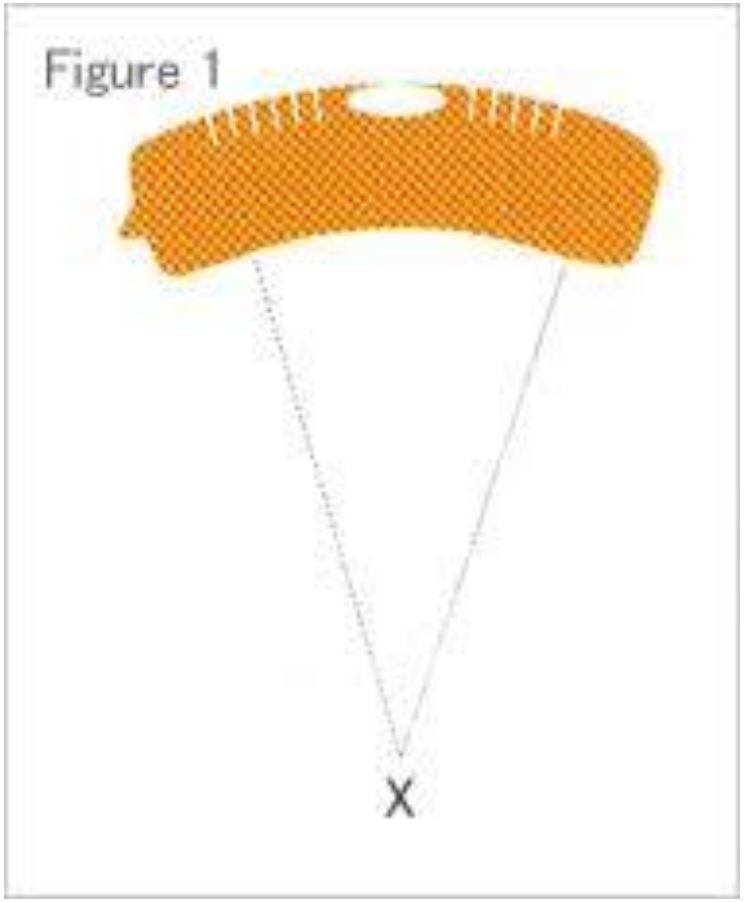
Range (mm)	Steps (mm)	No. of pieces
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25,50,75,100	25	4
1.0005	---	1
	Total	112

Angular Measurements –Spirit Level

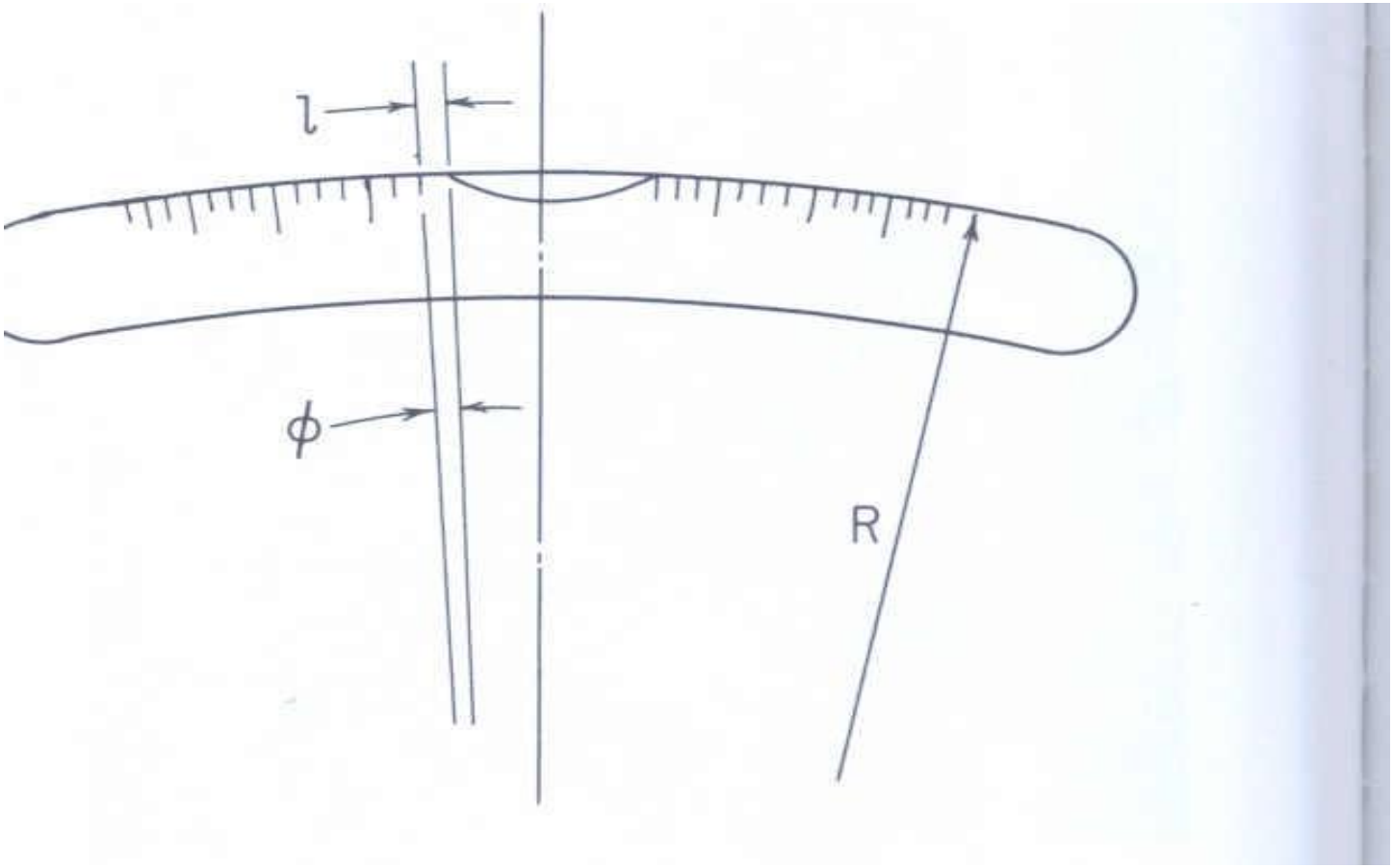




SPRIT LEVEL – ANGLE MEASUREMENT

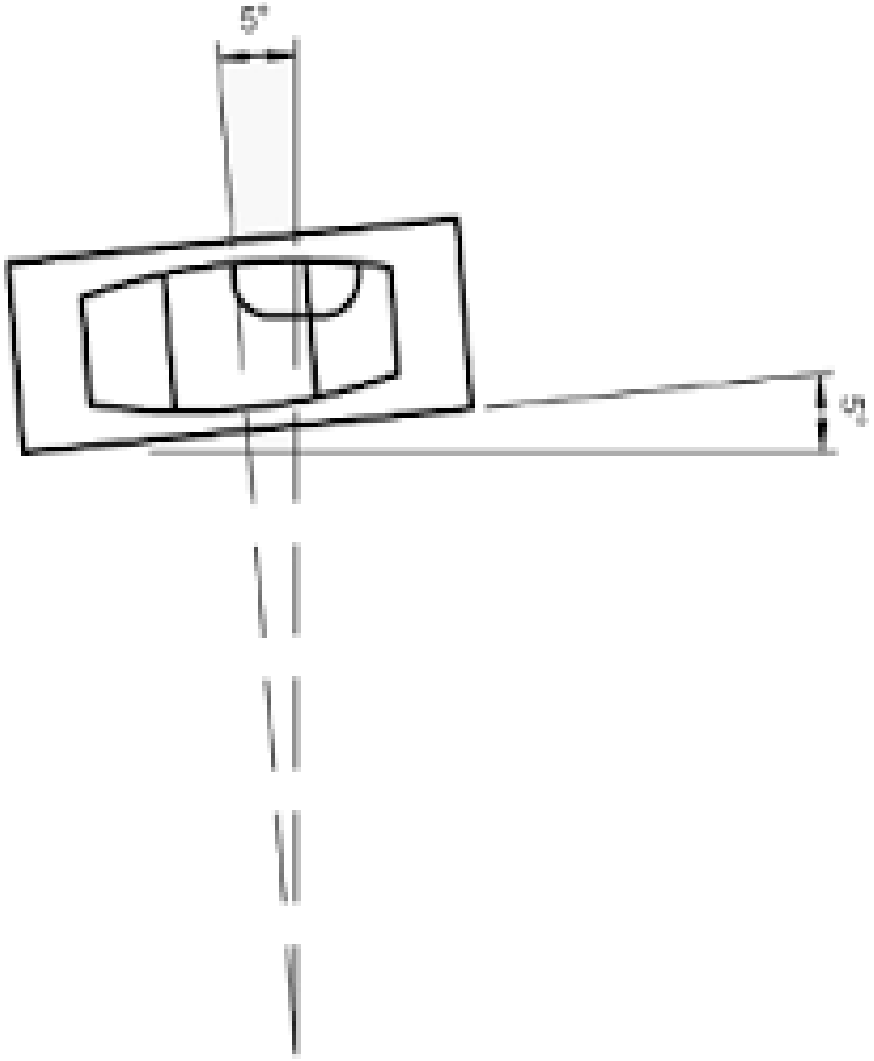


Angular Measurements –Spirit Level



$$l = R\phi$$

SPRIT LEVEL – ANGLE MEASUREMENT



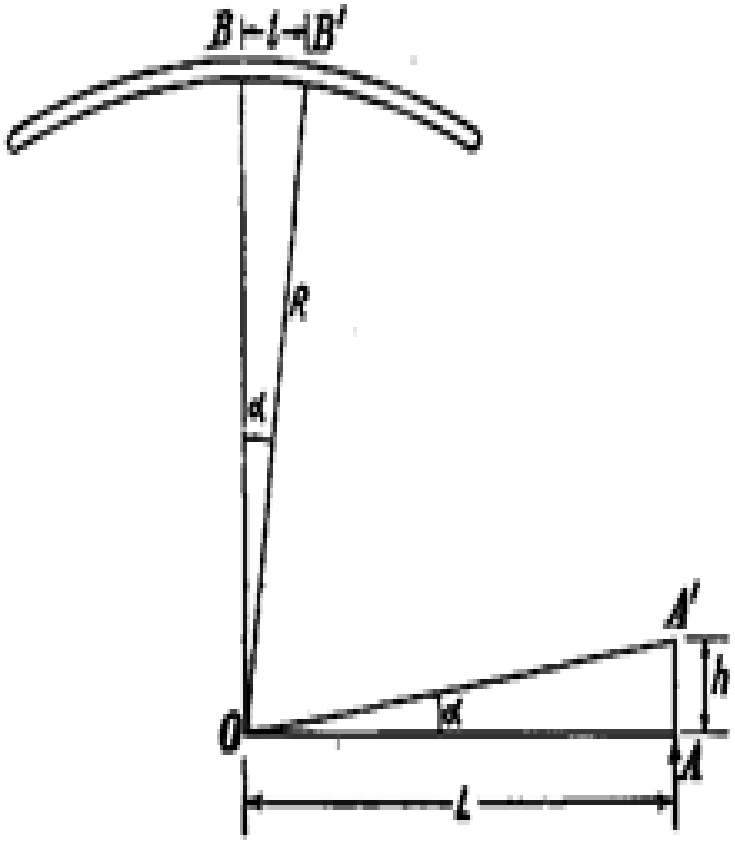


Fig. 2.69

Commonly used Gauges

- Master Setting Plugs/ Rings
- Limit Plug & Ring Gauges
- Snap gauges
- Taper Plug & Ring Gauges
- Radius Gauges
- Screw Pitch Gauges
- Feeler Gauges

Gauges –Master Setting Rings

Master Setting Rings are made to nominal size and are used to set the measuring instrument or comparator. Master Setting Plugs are also similar in application.

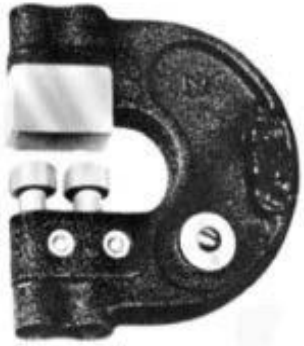
LIMIT GAUGES

- The "Go" side of the limit gauges should enter the hole (or cavity) or just pass over the shaft under the weight of the gauge without using any force.

- The "Not Go" side of the gauge must not enter or pass.

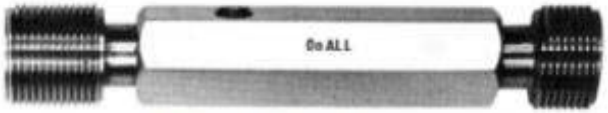
Limit Gauges

Cylindrical Pin Gauge



Adjustable Snap Gauge

Plain Ring Gauge



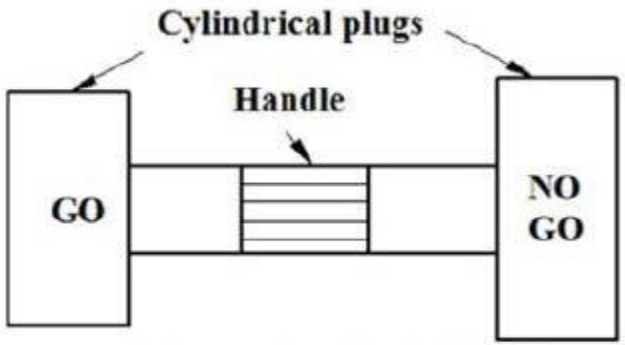
Thread Plug Gauge

Cylindrical Plug Gauge

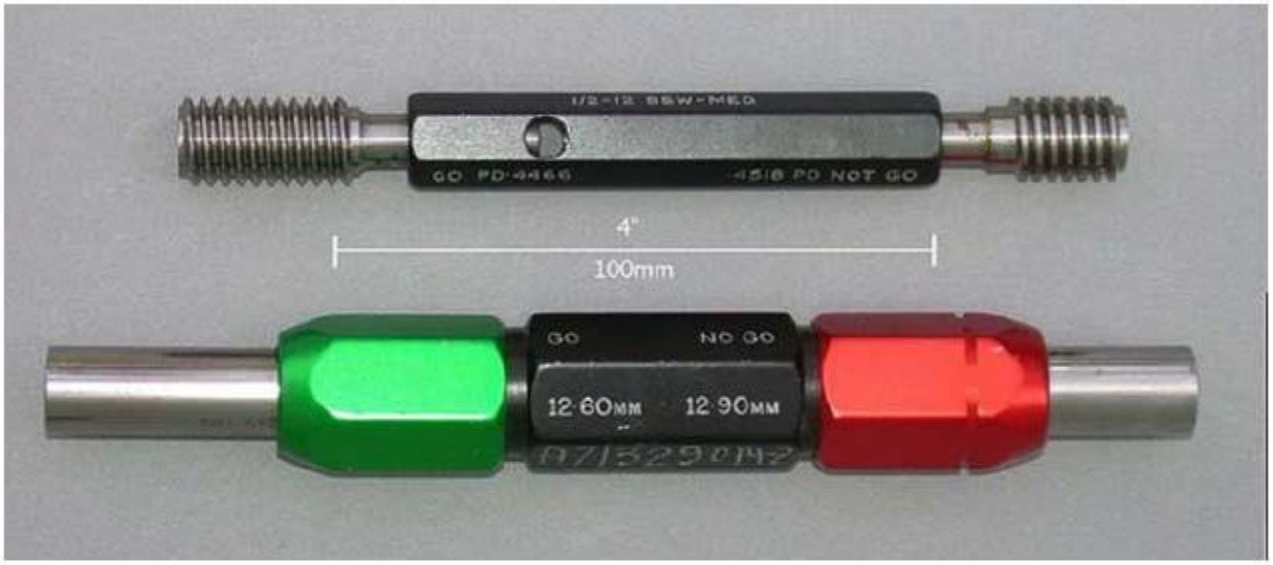
Progressive Cylindrical Plug Gauge

Adjustable Thread Ring Gauge

Limit Gauges



Double ended Plug Gauge

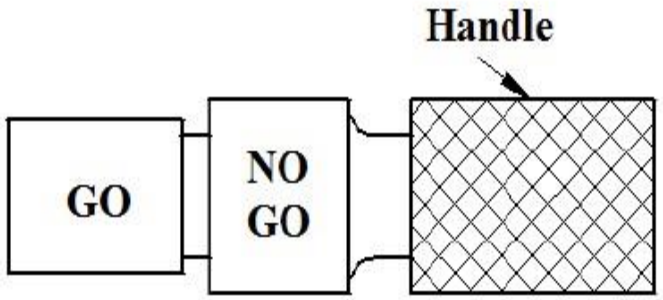


The handles of heavy plug gauges are made of light metal alloys while the handles of small plug gauges can be made of some nonmetallic materials.

LIMIT GAUGES

Progressive plug gauges:

For smaller through holes, both GO & NO GO gauges are on the same side separated by a small distance. After the full length of GO portion enters the hole, further entry is obstructed by the NO GO portion if the hole is within the tolerance limits.

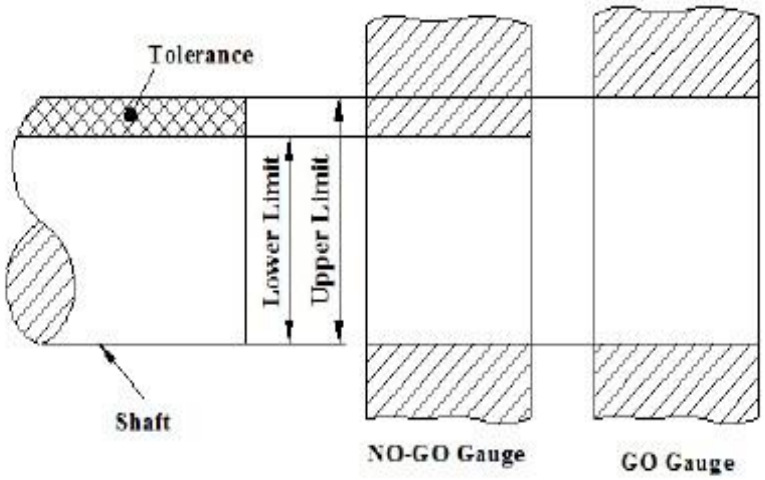


Progressive Plug Gauge

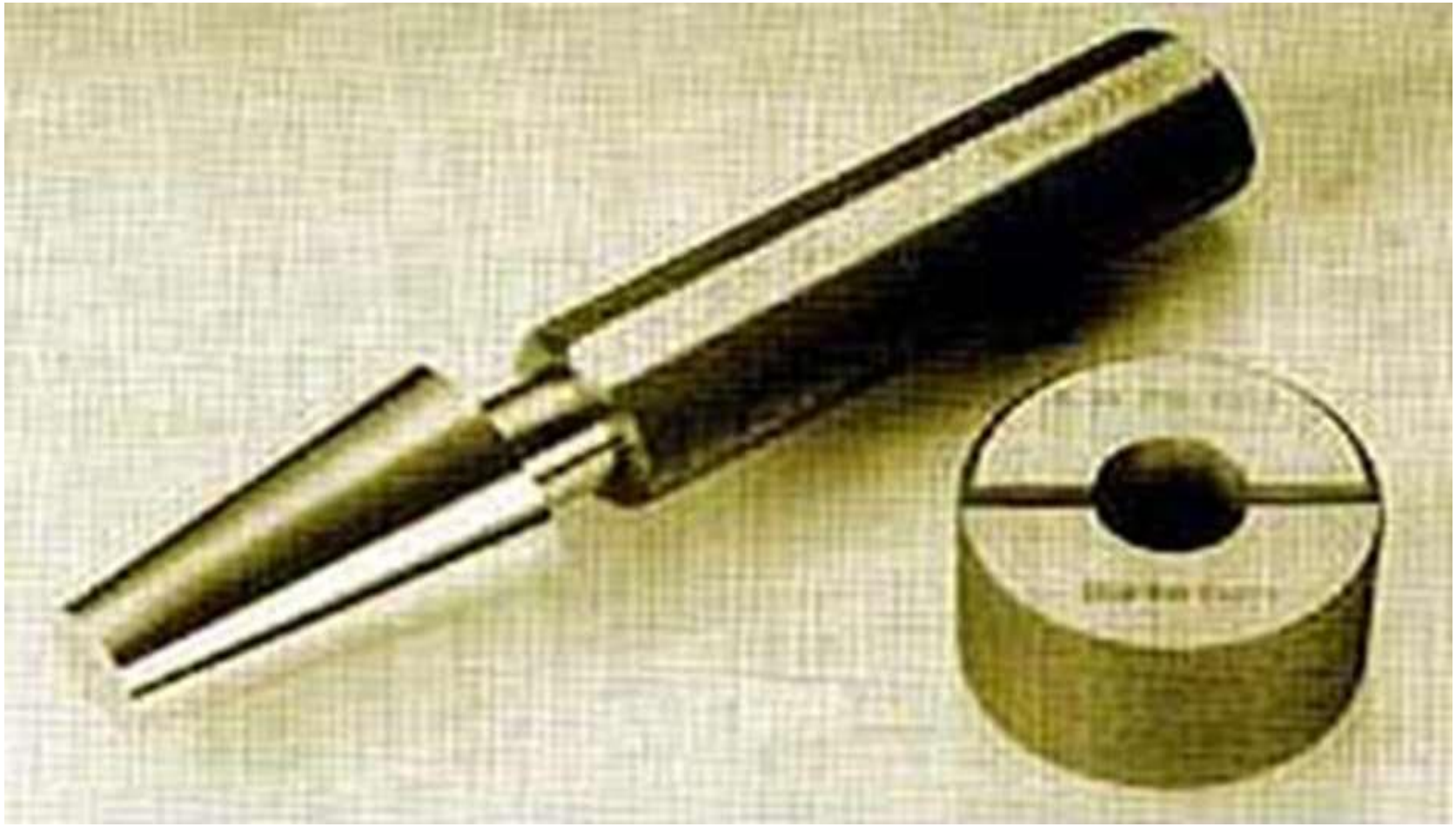
LIMIT GAUGES

Ring gauges:

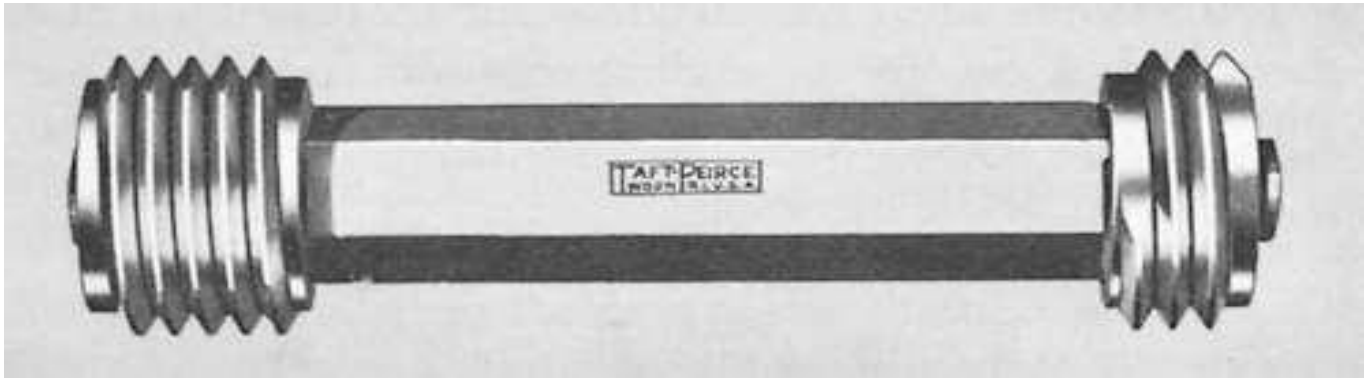
Ring gauges are used for gauging shafts. They are used in a similar manner to that of GO & NO GO plug gauges. A ring gauge consists of a piece of metal in which a hole of required size is bored.



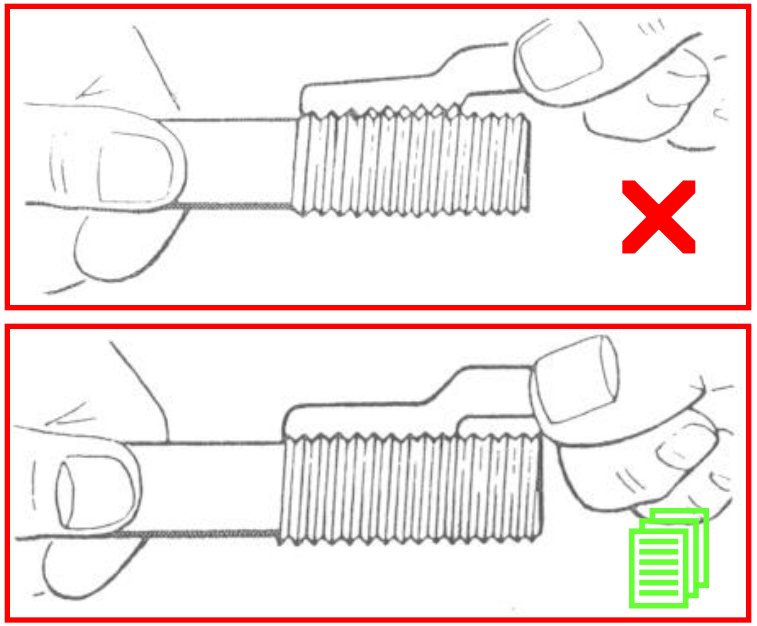
TAPER PLUG GAUGES



THREAD PLUG GAUGES



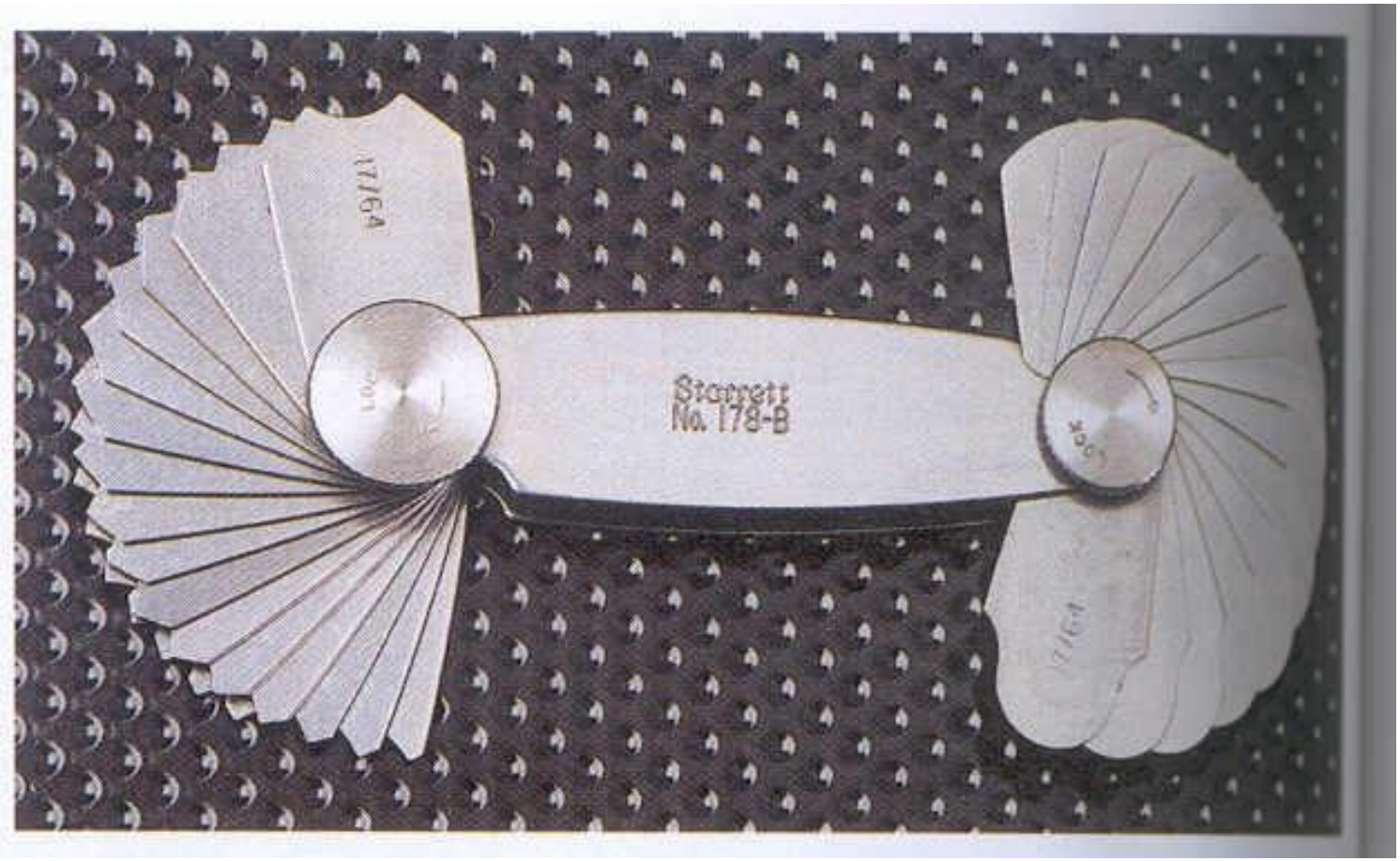
Gauges – Screw Pitch Gauges



A screw pitch gauge has a set of teeth which are of a known thread form. The gauge is used to determine the pitch of a thread on a bolt or screw of any diameter.

Note: Both Pitch gauges and thread, should be clean and free of burrs. It is useful to hold the screw up to a light to see small gaps. Use the full length of the gauge for greater accuracy.

Gauges – Radius Gauges



A radius gauge has a profile of a known radius. The gauge is used to determine the radius of any feature.

Gauges – Feeler Gauges

Feeler gauge has a known thickness. The gauge is used to find the gap between two parts.

We do look forward to your sustained interest!

THANK YOU!