IPE 381
Linear & Angular Measuring Instrument

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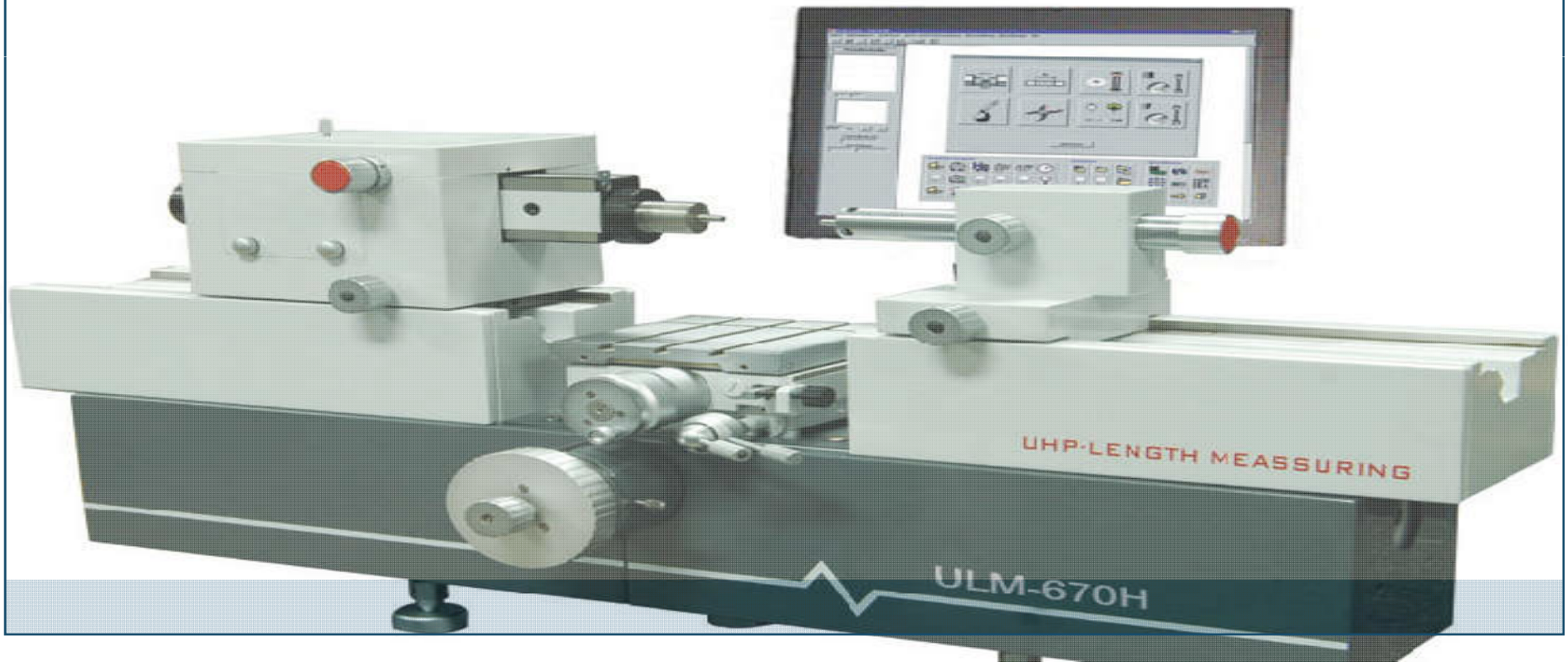


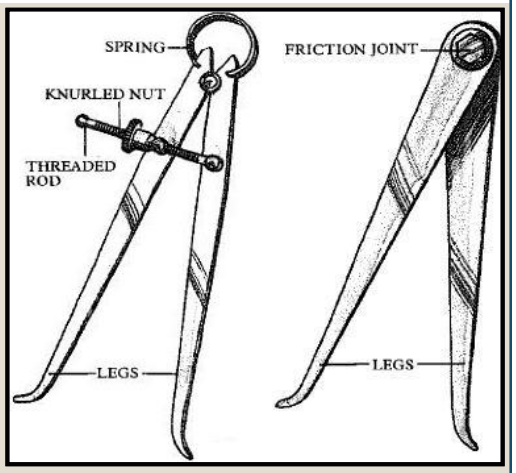
Outline

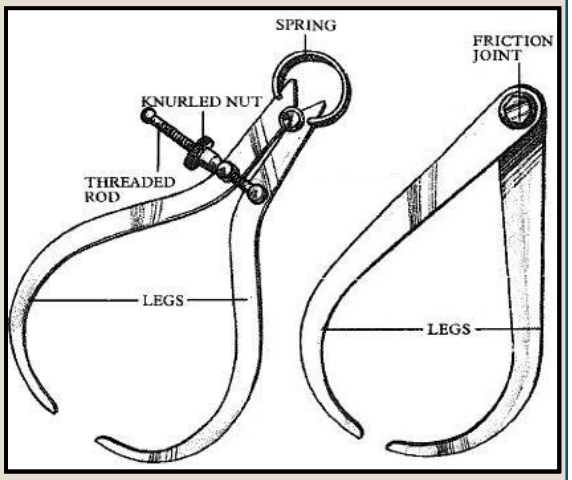
- Linear Measurements
  - Calipers
  - V-Block
  - Engineer's taper, wire & thickness gauge
  - Pitch Screw Gauge
  - Vernier Instruments
  - Micrometer
  - Telescopic Internal Gauge
  - Hemispherical Gauge
  - Slip Gauge
  - Pivotal Stylus & Autocollimator
  - Accessories
    - Surface Plate
    - Angle Plate
- Angular Measurements
  - Pin Gauge
  - Bevel Protractor
  - Sine Bar
  - Sprit Level
  - Autocollimator
- Miscellaneous Measurements

Reference : Engineering Metrology – by R.K. Jain

Linear Measurement

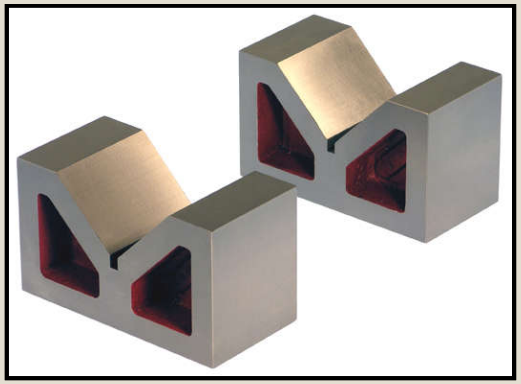
- Calipers
  - Consists of two legs
  - Accessory to scale
  - Reduce sighting errors and increase accuracy
  - Two types:
    - Firm Joint type
      - Outside
      - Inside
    - Spring type
      - Outside
      - Inside
      - Transfer
      - Hermophrodite

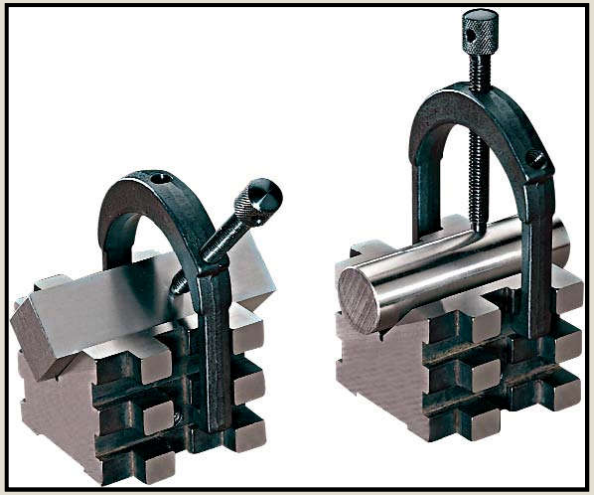




Linear Measurement

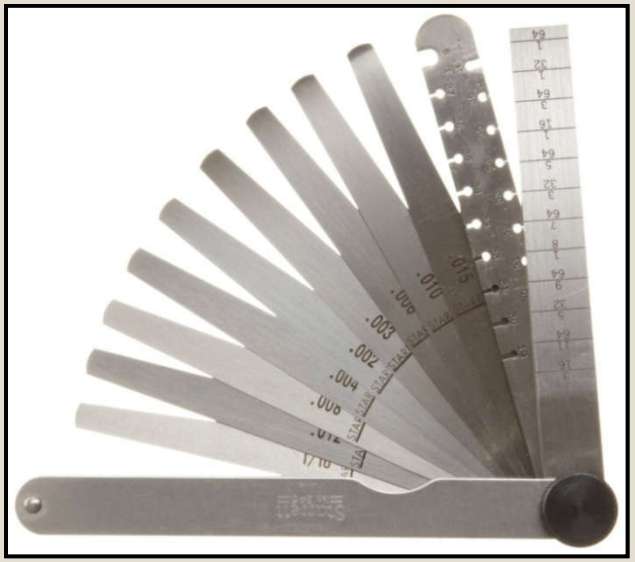
- V-Block
  - Checking roundness of cylindrical workpiece
  - Marking centers accurately
  - 90° angle
  - Types
    - Depending on accuracy
      - Grade A
      - Grade B
    - Depending on design
      - One vee
      - Two vee



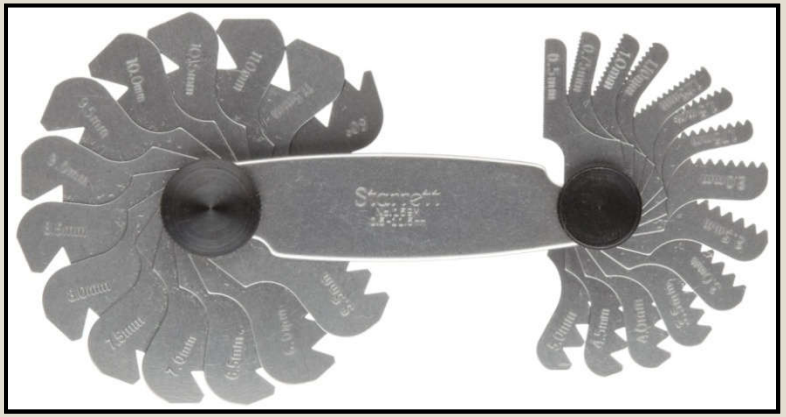


Linear Measurement

- Engineer's taper, wire & thickness gauge
  - Consists of leaves for
    - Taper measurement
    - Wire diameter measurement
    - Thickness of small gaps

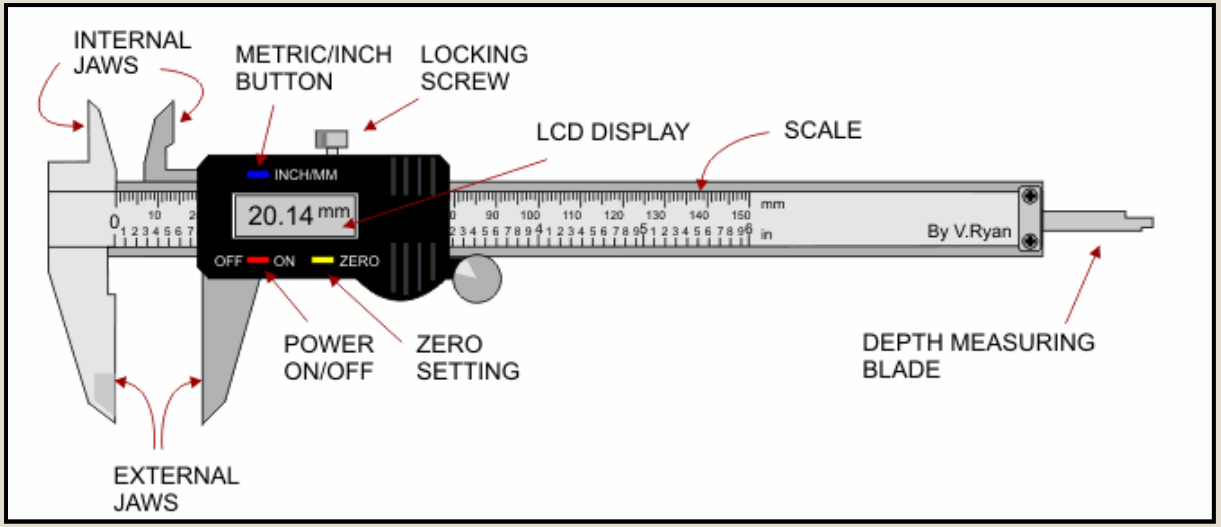


- Pitch Screw Gauge
  - Contains multiple leaves
  - Matches teeth on the leaves with teeth on work



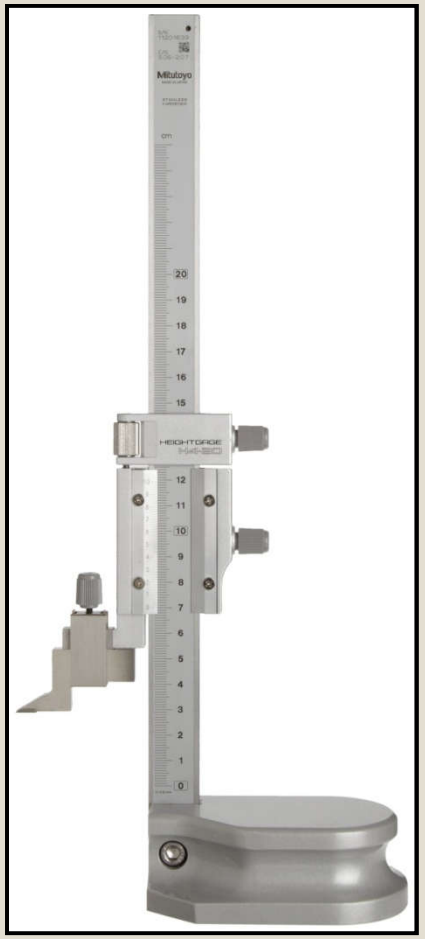
Linear Measurement

- Vernier Instruments
  - Two scales: Main & Vernier
  - Slight difference in divisions is used enhance the accuracy
  - Three elements: Beam, Fixed Jaw & Sliding Jaw
  - Errors in measurements
  - Digital Caliper



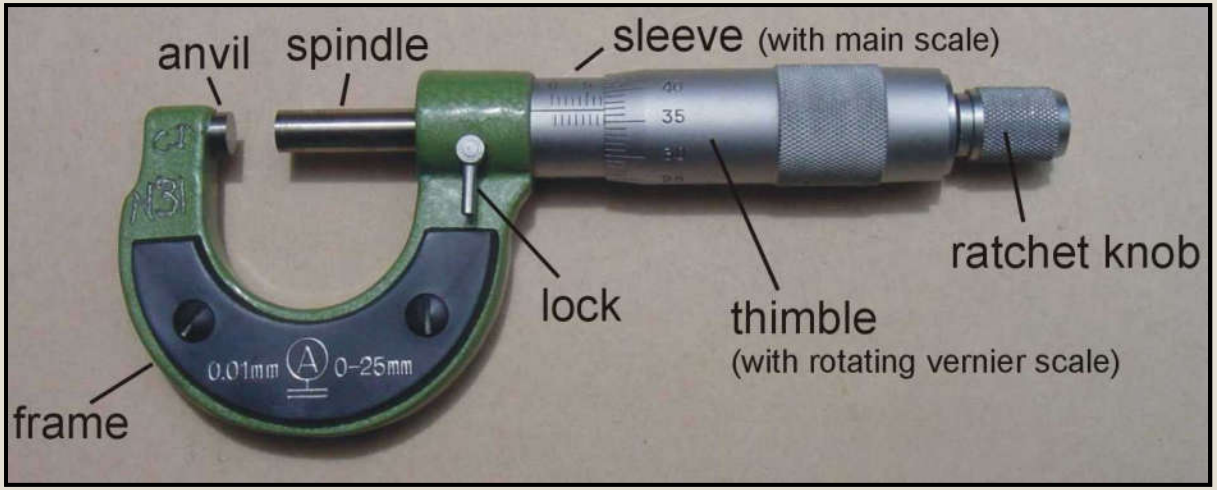
Linear Measurement

- Vernier Height Gauge
  - Sort of Vernier Caliper
  - Have attachment to make suitable for height measurement



Linear Measurement

- Micrometers
  - U shaped
  - Inside
  - Micrometer depth gauge



Linear Measurement

- Telescopic Internal Gauge

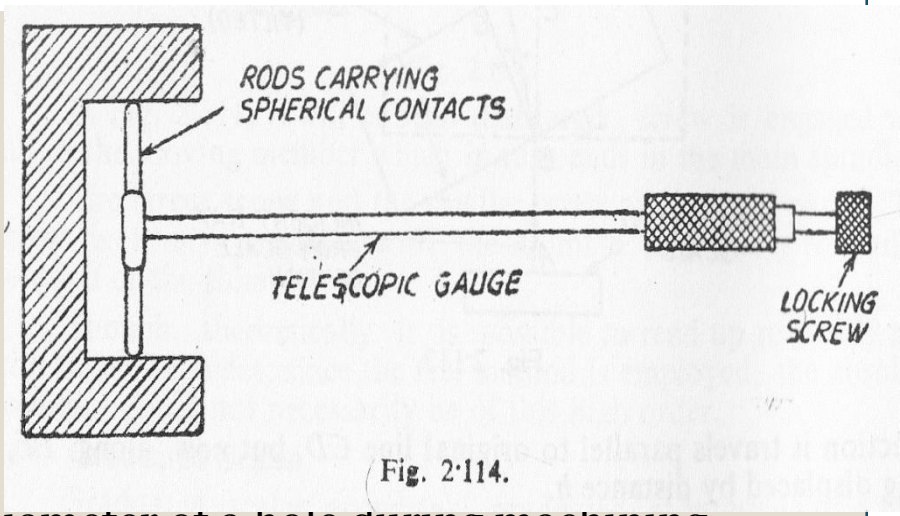


Fig. 2·114.

It is used for the measure-ment of internal diameter of a hole during machining operation (Fig). It consists of two spherical contacts carried on two rods. The two rods can slide within a tube and are forced apart by an internal spring. For taking the measurements the spring unit is compressed and inserted into the hole. The contacts then move out so as to press on the surface. They are then locked in position by means of a locking screw. The telescopic gauge is then taken out and the dimension across two tips is measured by some other external measuring instrument .Telescopic gauge can be used for big bores only.

- Telescopic Internal Gauge

Linear Measurement

- **Hemispherical Gauge**

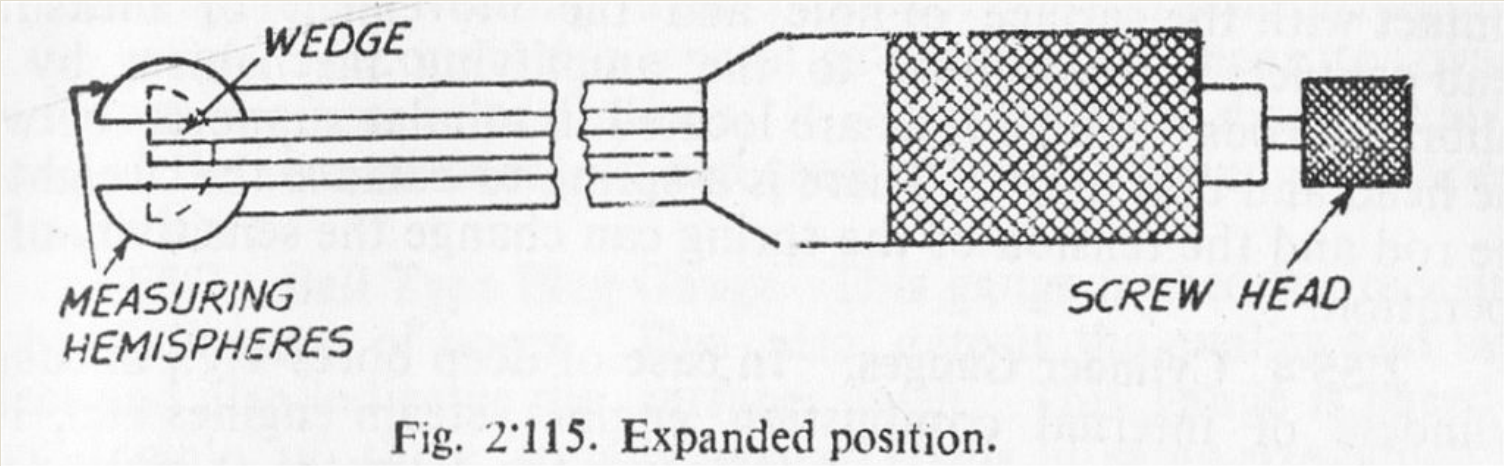


Fig. 2·115. Expanded position.

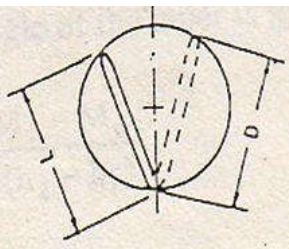
For the measurement of bores that are too small, hemispherical gauge is considered to be very useful. It consists of the spring steel arms having hemispherical ends, within which is a wedge shaped member attached to a spindle which can be moved endwise by a knurled head (Fig).Thus the hemispheres can be expanded or contracted by the movement of the wedge. Again this gauge is also operated by the sense of feel.

Linear Measurement

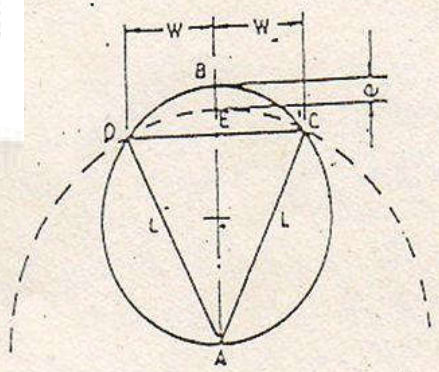
- Pin Gauge
  - For larger bores
  - Has spherical ends
  - Length is slightly less than the diameter to be measured

$$AE.EB = DE.EC = W^2$$

$$AE^2 = AC^2 - EC^2$$



(a)



(b)

Fig. 4.3: Measurement of bore by pin gauge

$$D = AE + EB$$

$$= \sqrt{L^2 - W^2} + \frac{W^2}{\sqrt{L^2 - W^2}}$$

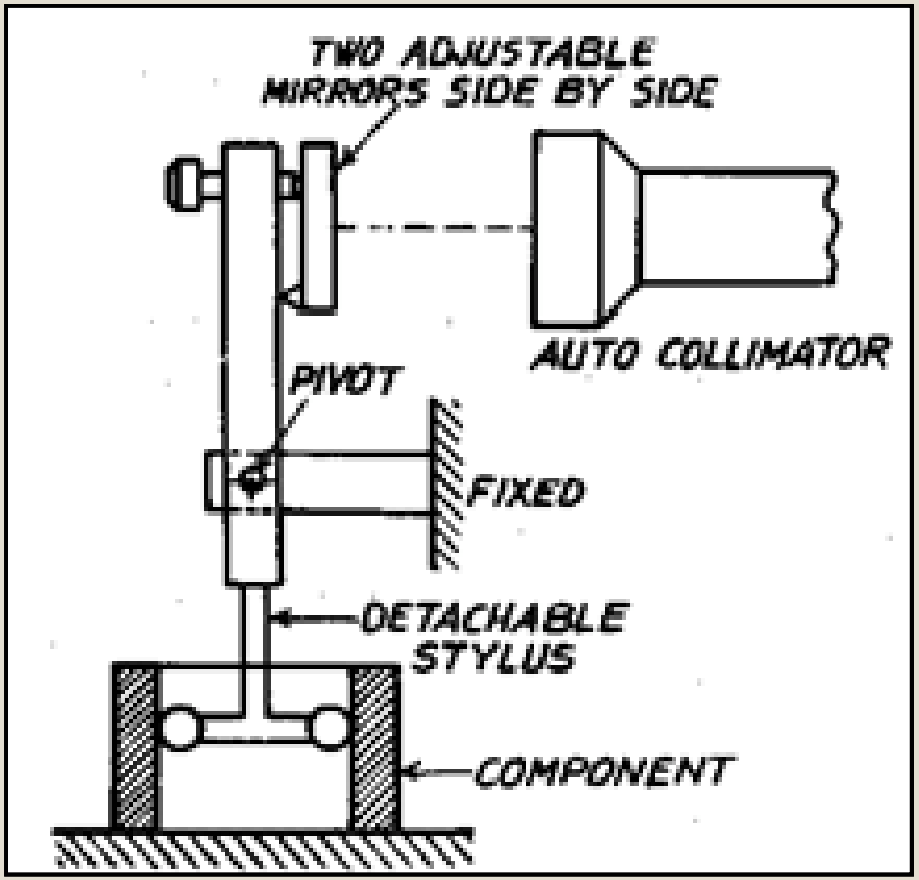
$$= \frac{L^2}{\sqrt{L^2 - W^2}}$$

It may be simplified (applying binomial theorem) as

$$D = L^2 (L^2 - W^2)^{-1/2} = L\left(1 - \frac{W^2}{L^2}\right)^{-1/2} = \left(L + \frac{W^2}{2L^2}\right)$$

Linear Measurement

- Pivotal Stylus & Autocollimator



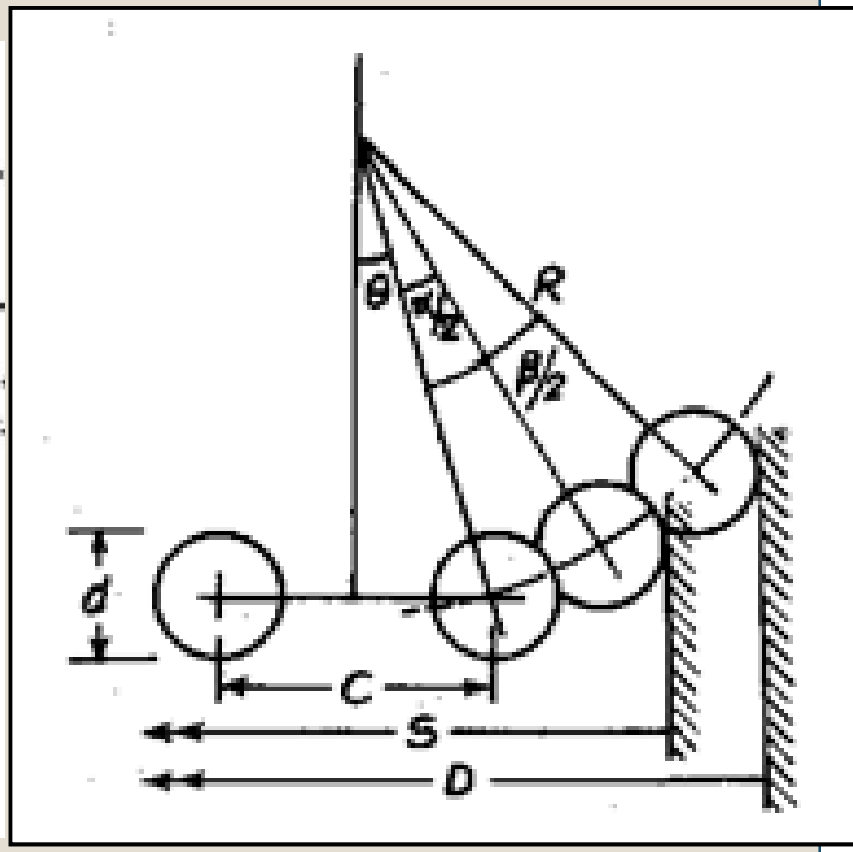
Linear Measurement

$$\frac{D}{2} - \frac{d}{2} = R\sin\left(\theta + \frac{\beta}{2}\right)$$

$$\frac{S}{2} - \frac{d}{2} = R\sin\left(\theta + \frac{\alpha}{2}\right)$$

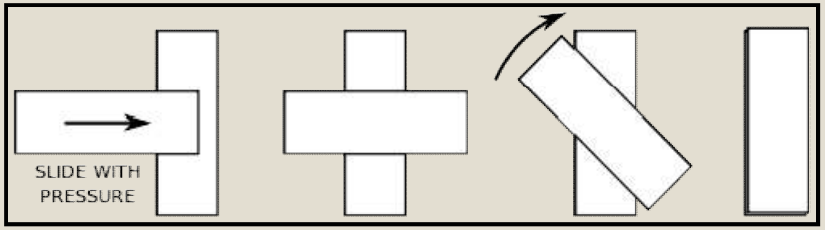
$$\frac{D-S}{2} = R\sin\left(\theta + \frac{\beta}{2}\right) - R\sin\left(\theta + \frac{\alpha}{2}\right)$$

$$D - S = 2R\left[\sin\left(\theta + \frac{\beta}{2}\right) - R\sin\left(\theta + \frac{\alpha}{2}\right)\right]$$

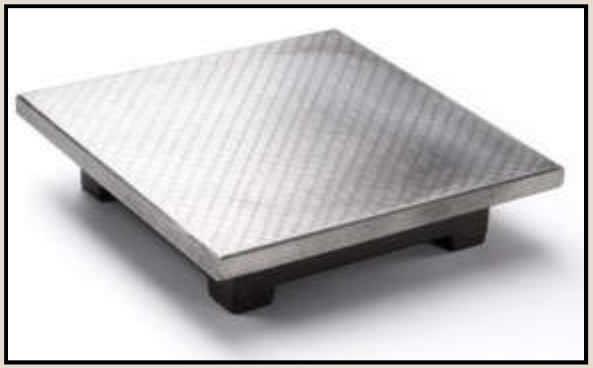


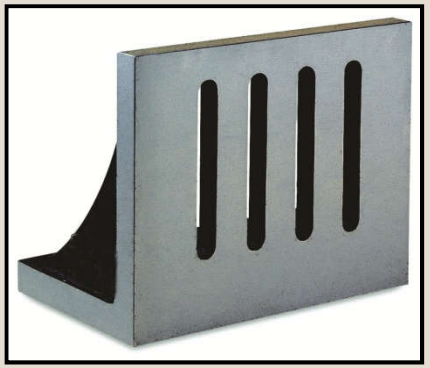
Linear Measurement

- Slip Gauge
  - Rectangular blocks of 30 by 10 mm
  - Surface hardened
  - Wrung together due to fine finish (6-7 x 10^{-6}mm)



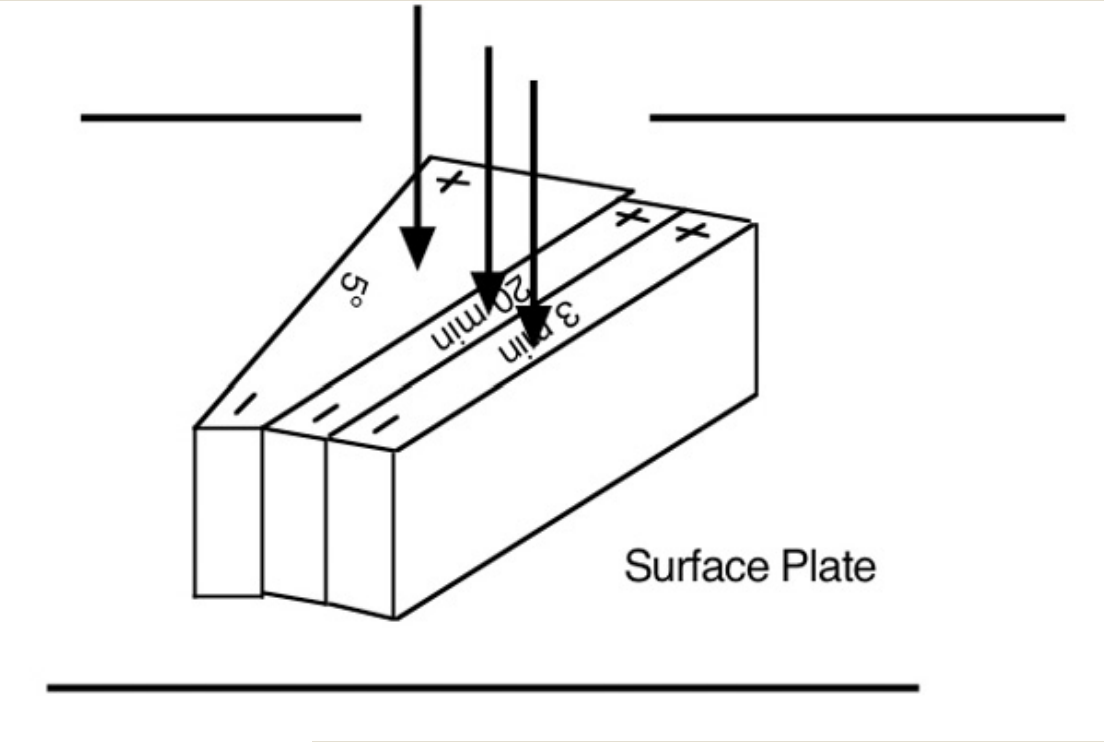
- Accessories
  - Surface Plate
  - Angle Plate

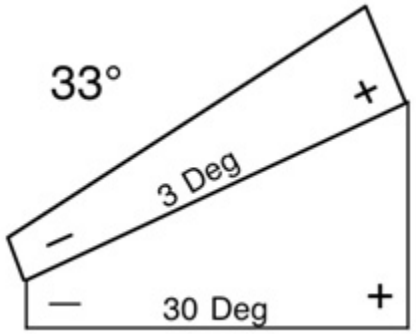


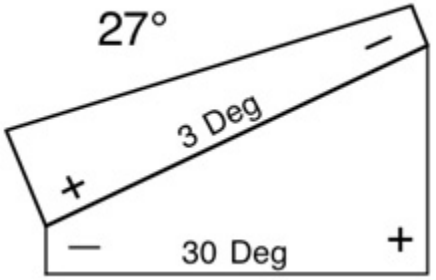


Angular Measurement

- Angle Gauge

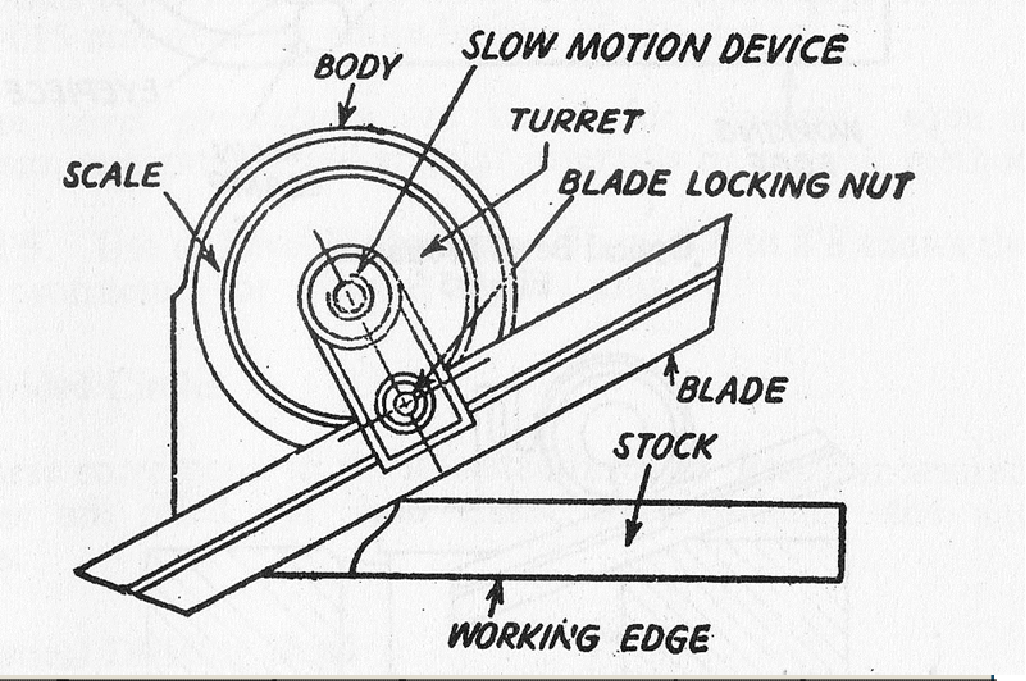






Angular Measurement

- Bevel Protractor (also see combination gauge)
  - Base plate contains a main scale with which there is an attached vernier scale. Adjustable blade moves along the circular periphery of the main scale.
  - Various components:
    - Body
    - Stock
    - Blade
  - Use of bevel protractor
    - Checking inside bevel face
    - Checking vee block
    - Measuring acute angle

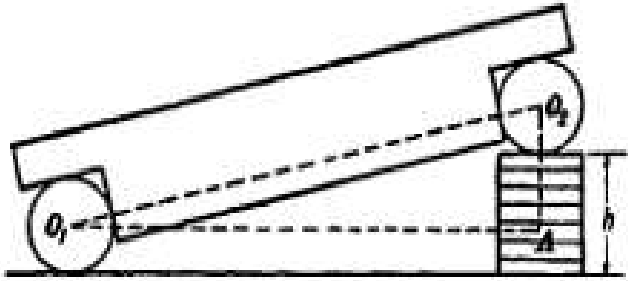


Angular Measurement

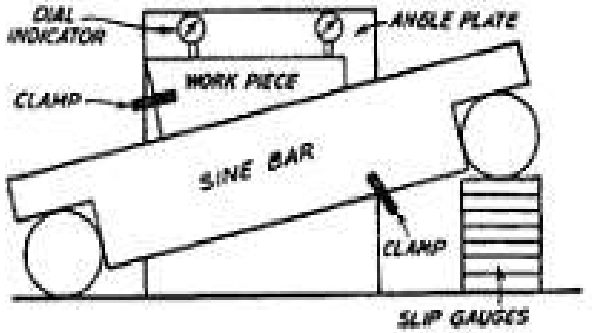
- Sine Bar
  - Uses the ratio of the length of two sides of a right triangle in deriving a given angle.
  - Measurement is usually limited to 45°
  - Not complete: needs surface plate, slip gauges & indicating device.
  - Made from high carbon, high chromium, corrosion resistant steel

Use of Sine Bar

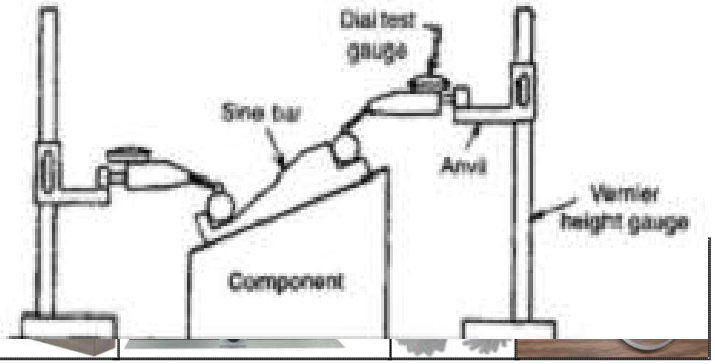
(1) Measuring known angles or locating any work to a given angle.



(2) Checking of unknown angles.

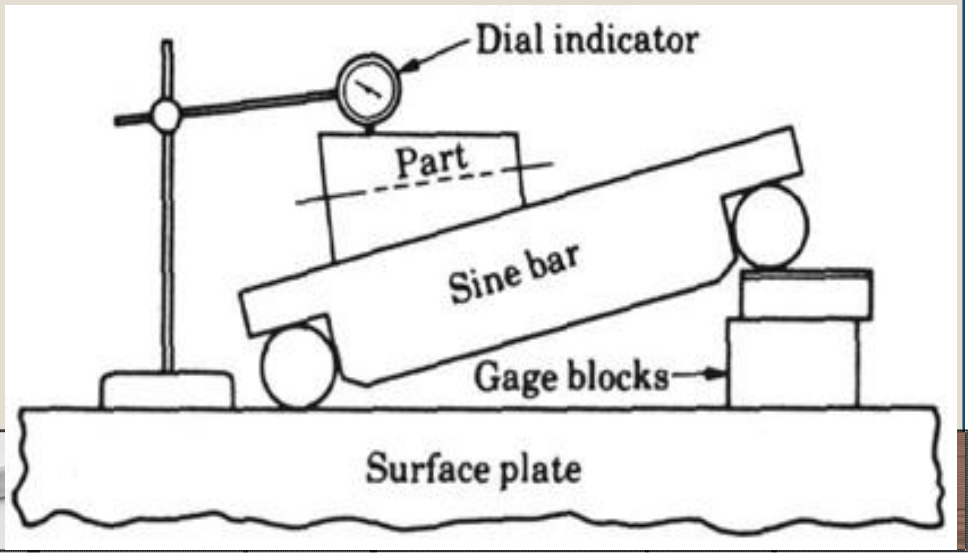


(3) Checking of unknown angles of heavy component.



Angular Measurement

- Accuracy of sine bar depends on following features:
  - Two rollers must have equal diameter and be true cylinders
  - The rollers must be set parallel to each other and to the upper face
  - The precise center distance between the rollers must be known
  - The upper surface must have a high degree of flatness



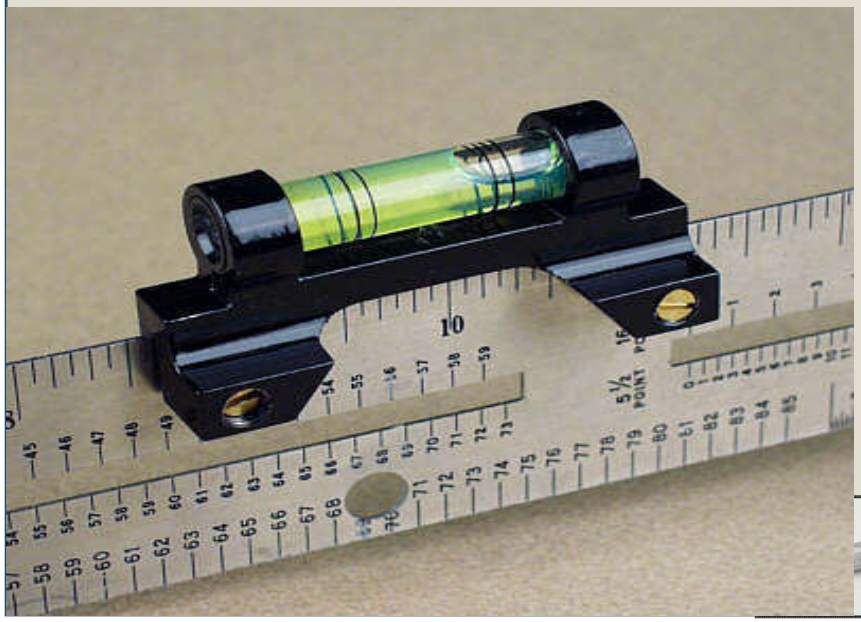
Limitations of Sine Bars

The sine bars inherently become increasingly impractical and inaccurate as the angle exceeds 45° because of following reasons:

- The sine bar is physically clumsy to hold in position.
- The body of the sine bar obstructs the gauge block stack, even if relieved.
- Slight errors of the sine bar cause large angular errors.
- Long gauge stacks are not nearly as accurate as shorter gauge blocks.
- Temperature variation becomes more critical.
- A difference in deformation occurs at the point of roller contact to the support surface and to the gauge blocks

Angular Measurement

- Sprit Level
  - Purpose: Measuring small angle and positioning surface parallel to horizontal or vertical plane
  - Consists of sealed glass tube on which scale is engraved. Tube is filled with ether leaving the top part for ether vapor which forms a bubble



Angular Measurement

- Sprit Level

For small angle,

$\sin\theta = \tan\theta = \theta$(in radian)

$$h = L\alpha$$

$$arc\ l = R\alpha$$

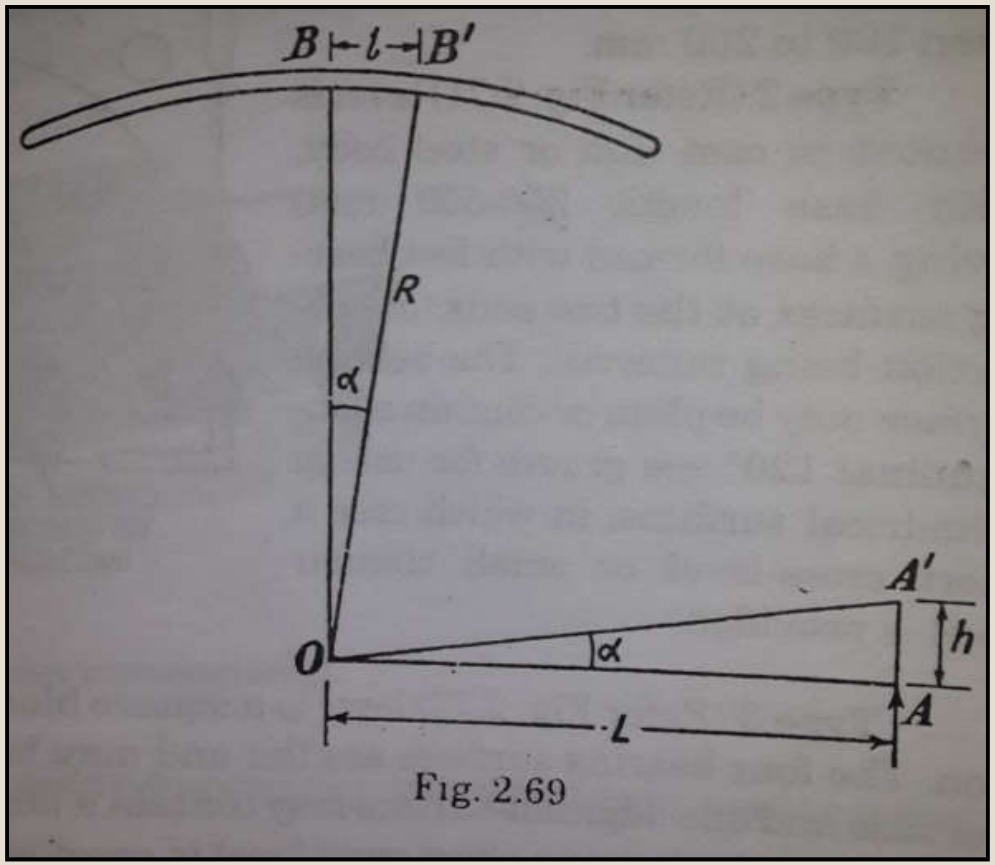


Fig. 2.69

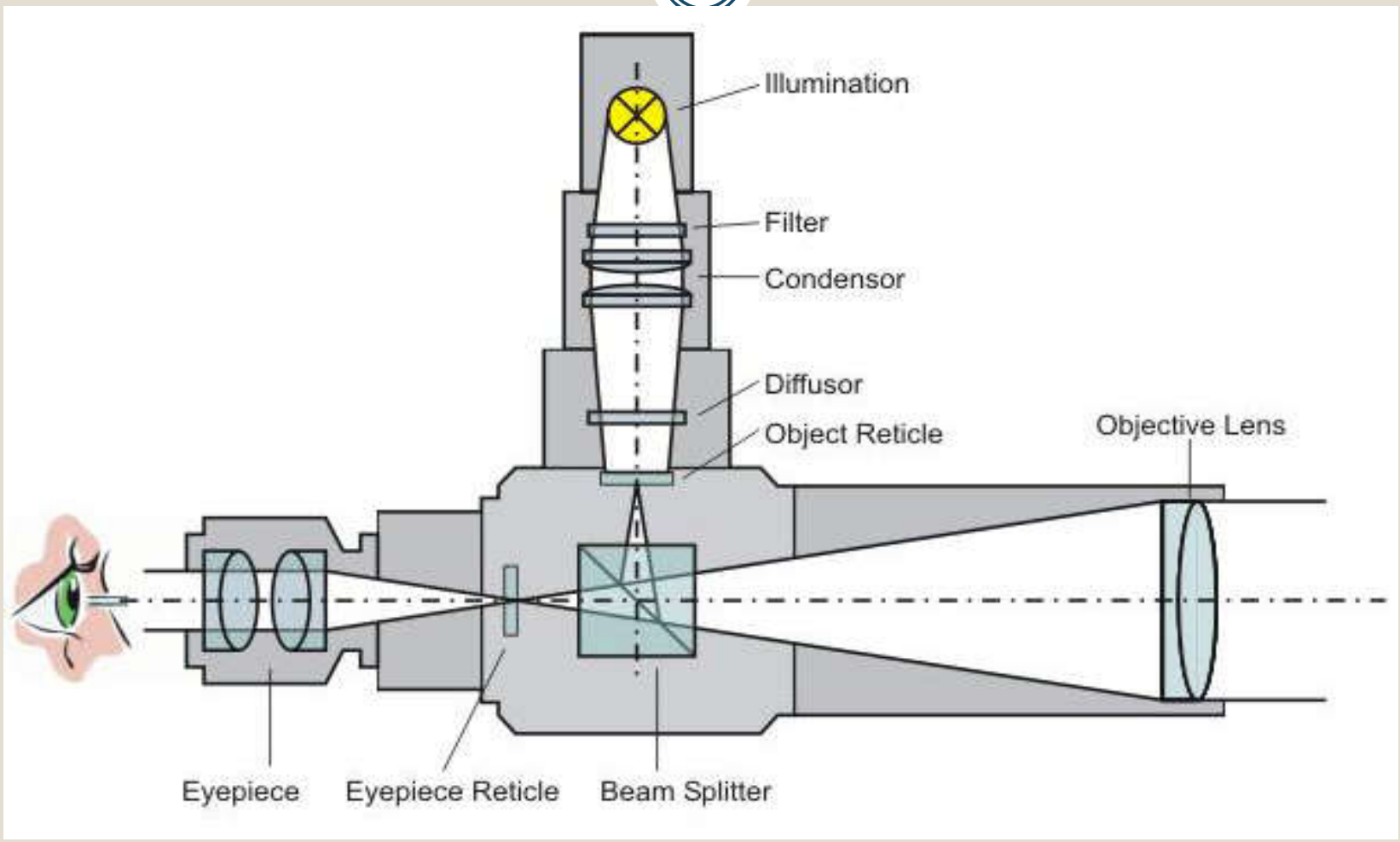
Angular Measurement

- Characteristic element of a level (see in details)
  - **Sensitivity** : expressed as **the angle** of tilt in seconds for which bubble will move by one division on the tube
    - Sensitivity = Angle in seconds/1 division of tube
  - Constant of sprit level: change in tilt, expressed in mm/m
  - Accuracy of level: base should be flat within prescribed limits
  - Errors: due to error in the vial, curvature being non-uniform, scale positioned incorrectly and temperature variations

Angular Measurement

- Autocollimator
  - Infinity telescope and collimator combined into one
  - An optical instrument used for small angular differences
  - Provides very sensitive and accurate approach
- Application
  - Measurement of straightness and flatness
  - Precise angular indexing
  - Assessment of squareness
  - Parrallelism of components

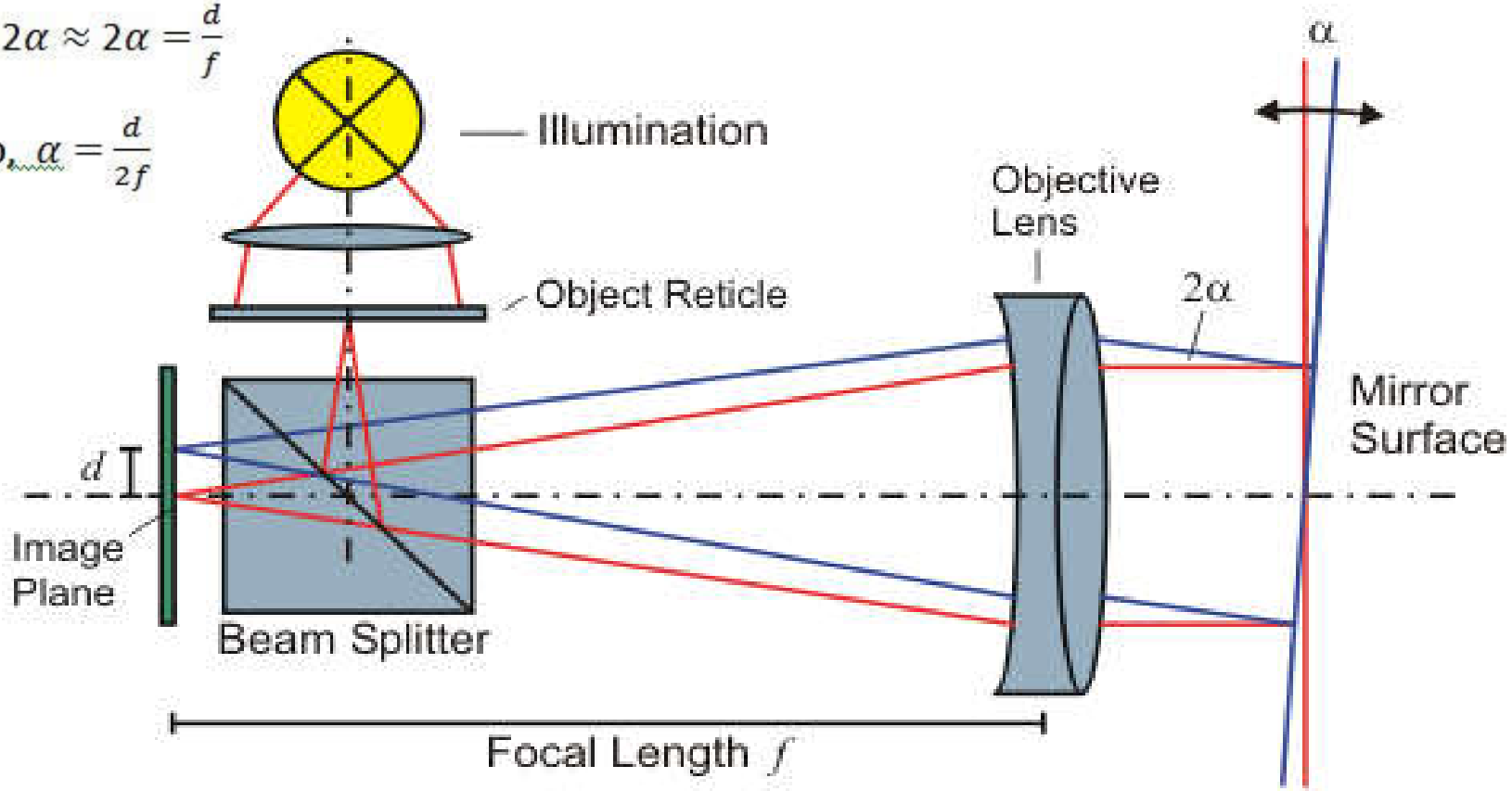
Angular Measurement



Angular Measurement

$\tan 2\alpha \approx 2\alpha = \frac{d}{f}$

So, $\alpha = \frac{d}{2f}$



THAT IS ALL FOR TODAY