



## MODULE 3

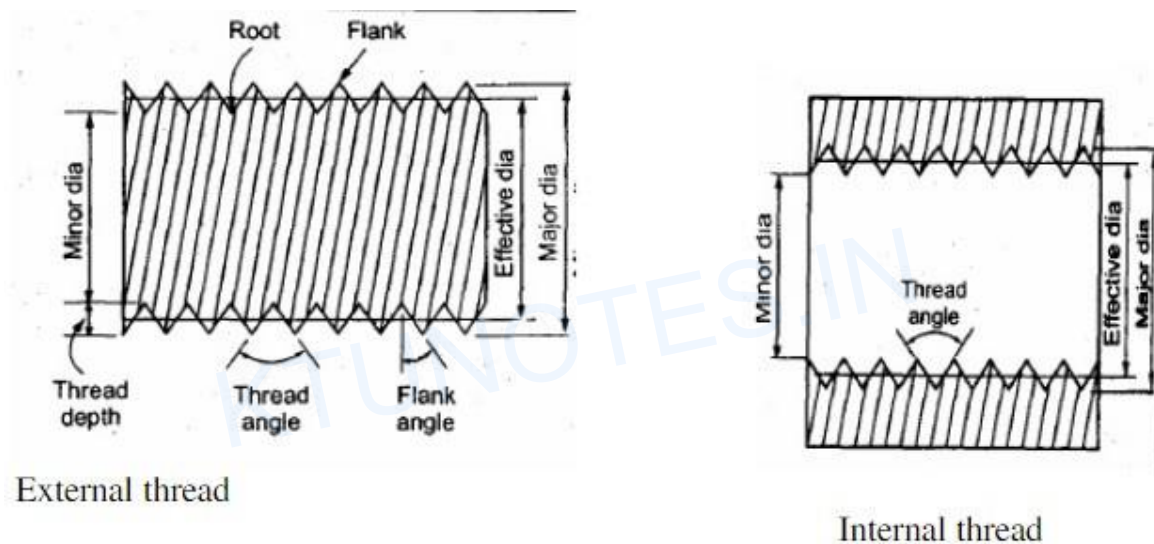
## 3. SCREW THREAD MEASUREMENT

## INTRODUCTION

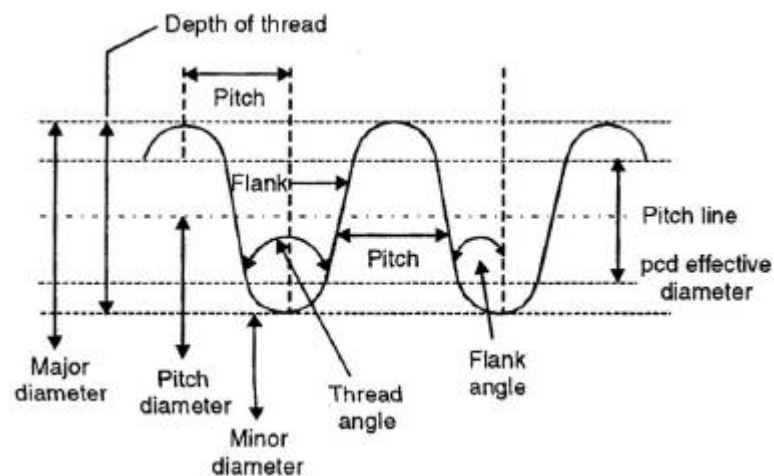
Screw threads are used to transmit the power and motion, and also used to fasten two components with the help of nuts, bolts and studs.

There is a large variety of screw threads varying in their form, by included angle, head angle, helix angle etc.

The screw threads are mainly classified into 1) External thread 2) Internal thread



## SCREW THREAD TERMINOLOGY



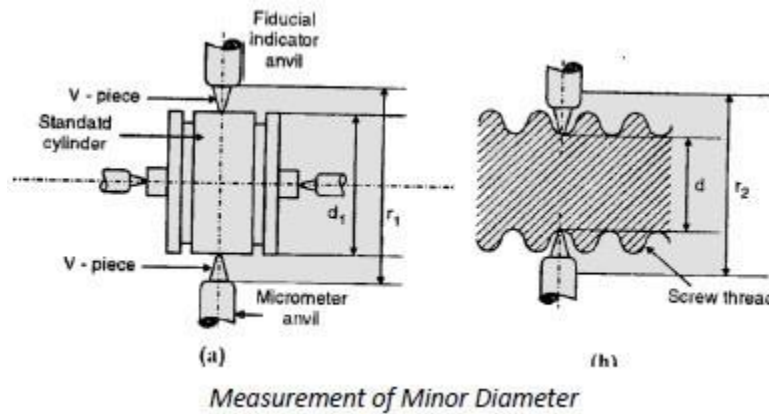
- **Lead:** The axial distance advanced by the screw in one revolution is the lead.
- **Pitch:** It is the distance measured parallel to the screw threads axis between the corresponding points on two adjacent threads in the same axial plane. The basic pitch is equal to the lead divided by the number of thread starts.
- **Minor diameter:** It is the diameter of an imaginary co-axial cylinder which touches the roots of external threads.
- **Major diameter:** It is the diameter of an imaginary co-axial cylinder which touches the crests of an external thread and the root of an internal thread.
- **Pitch diameter:** It is the diameter at which the thread space and width are equal to half of the screw thread
- **Helix angle:** It is the angle made by the helix of the thread at the pitch line with the axis. The angle is measured in an axial plane.
- **Flank angle:** It is the angle between the flank and a line normal to the maxis passing through the apex of the thread.
- **Height of thread:** It is the distance measured radially between the major and minor diameters respectively.
- **Depth of thread:** It is the distance from the tip of thread to the root of the thread measured perpendicular to the longitudinal axis.
- **Form of thread:** This is the shape of the contour of one complete thread as seen in axial section.
- **External thread:** A thread formed on the outside of a work piece is called external thread.
- **Internal thread:** A thread formed on the inside of a work piece is called internal thread.
- **Axis of the thread:** An imaginary line running longitudinally through the center of the screw is called axis of the thread.
- **Angle of the thread:** It is the angle between the flanks or slope of the thread measured in an axial plane.

#### MEASUREMENT OF VARIOUS ELEMENTS OF THREAD

##### (a) Measurement of Minor Diameter (Floating Carriage Micrometer):

- Floating carriage micrometer is used to measure the minor diameter. It is suitable for almost all kinds of threads.
- The V-piece is available in various sizes having suitable radii at the edge. The standard is kept between the micrometer anvils with the help of V- pieces as shown in Figure. The fiducially indicator anvil is used to maintain the same constant pressure at the time of measurement.
- The diameter of standard cylinder is known to us and the reading is taken for the V pieces in position as  $r_1$ . Now without changing the position of fiducially indicator anvil, the standard cylinder

is replaced by screw. The reading is now taken for the screw thread in position as  $r_1$ . If  $d$  is the minor diameter of a screw thread then the value of  $d$  can be calculated as,



Minor dia.  $d = (\text{diameter of standard cylinder}) \pm (\text{difference between the readings})$

$$d = d_1 \pm (r_2 - r_1)$$

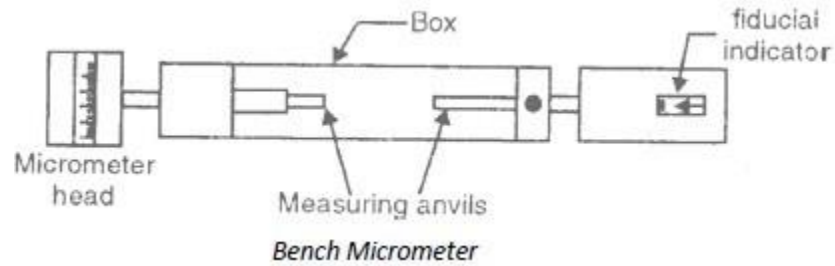
#### (b) Measurement of Major Diameter:

- The major diameter of the screw threads can be checked by the use of micrometer or vernier callipers as in plain diameter measurement. The major diameter is measured by bench micrometer as shown in the figure.
- It uses constant measuring pressure i.e. the measurements are made at the same pressure. Fixed anvil is replaced by fiducially indicator Figure.
- The work piece is held in hand and the machine can be used as a comparator to avoid the pitch errors of micrometers.
- Instead of slip gauge, a calibrated setting cylinder is used as a setting standard, as it gives similarity of contact at the anvils. The cylinder is held and the readings of micrometer are noted.
- The diameter of setting cylinder is approximately equal to the major diameter. The cylinder is replaced by threaded work pieces and the readings are noted for the same reading of fiducial indicator.

$r_1$  = reading of micrometer on setting cylinder

$r_2$  = micrometer reading on the thread

Then major diameter =  $d_1 + (r_2 - r_1)$



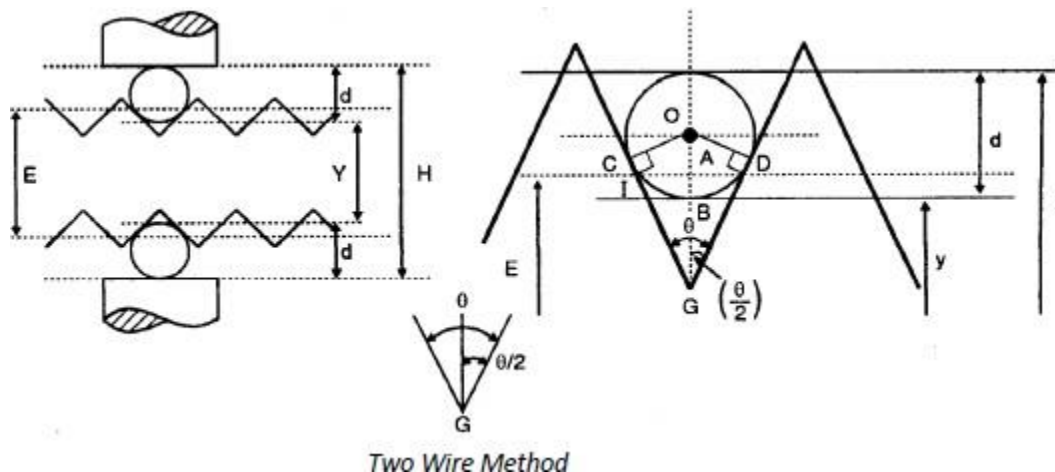
### (c) Effective Diameter:

- It is defined as the diameter of the imaginary co-axial cylinder intersecting the thread in such a manner that the intercept is on the generator of the cylinder.
- It represents the size of flanks and is the most important diameter of the thread. The effective diameter or pitch diameter can be measured by the following methods:

- Two wires or three wire method.
- Micrometer method.

#### 1) Measurement of Effective Diameter by Two Wire Method:

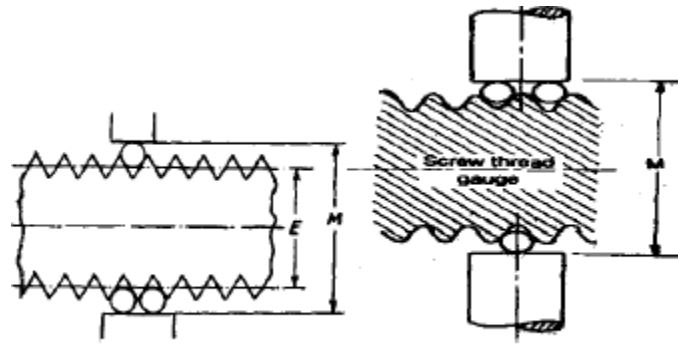
- The wires used are made of hardened steel to sustain the wear and tear. It may be given high degree of accuracy and finish by lapping to suit various pitches.
- The effective diameter of a screw thread may be assured by placing two wires or rods of identical diameter between the flanks of thread.



#### 2) Three wire method:

In this method three Wires of equal and precise diameter are placed in the thread grooves at opposite sides of the screw and measuring the distance  $M$  over the outer surfaces of the wires with the micrometer

- Out of the three wires in the set two wires are placed on one side and the third on the other side as shown in Fig.



*Three Wire Method of Measuring Effective Diameter*

- The wires are either held in hand or secured in the grooves by applying grease in the threads or by sticking the ends of the wires Vaseline. These wires may also be hung through threads on a stand. Any such method, however, must ensure freedom to the wires to adjust them self under the micrometer pressure.

This method ensures the alignment of micrometer anvil faces parallel to the thread axis. Therefore, this method of measuring effective diameter is more accurate. The effective diameter can now be calculated with following known elements:

The reading of the micrometer  $M = E + Q$ ,

Where  $E$  = effective diameter and  $Q$  is the constant depending upon the wire diameter and flank angle.

$$Q = W (1 + \operatorname{cosec} \theta) - (p/2) \cot \theta \text{ where } w = \text{diameter of the pitch and } p = \text{pitch, the thread angle } \theta$$

$$\text{Thus the effective diameter } E = M - Q = M - \{W (1 + \operatorname{cosec} \theta) - (p/2) \cot \theta\}$$

## SURFACE ROUGHNESS

Surface roughness indicates the state of a machined surface. For example, when representing the surface of a component, surface roughness can be examined by eye or rubbed with a fingertip. Expressions used to describe surface roughness include "shiny and pretty," or "like a mirror." Those differences are caused by the differences in the irregularities of the component surfaces.

### WHY DO WE MEASURE SURFACE ROUGHNESS?

The shape and size of irregularities on a machined surface have a major impact on the quality and performance of that surface, and on the performance of the end product. The quantification and management of fine irregularities on the surface, which is to say, measurement of surface roughness, is necessary to maintain high product performance.

Quantifying surface irregularities means assessing them by categorizing them by height, depth, and interval. They are then analyzed by a predetermined method and calculated per industrial quantities standards. The form and size of surface irregularities and the way the finished product will be used determine if the surface roughness acts in a favourable or an unfavourable way. Painted surfaces should be easy for paint to stick to, while drive surfaces should rotate easily and resist wear. It is important to manage surface roughness so that it is suitable for the component in terms of quality and performance.

### SURFACE METROLOGY CONCEPTS

Surface irregularities primarily arise due to the following factors:

1. Feed marks of cutting tools
2. Chatter marks on the work piece due to vibrations caused during the manufacturing operation
3. Irregularities on the surface due to rupture of work piece material during the metal cutting operation
4. Surface variations caused by the deformation of work piece under the action of cutting forces
5. Irregularities in the machine tool itself like lack of straightness of guide ways

### TERMINOLOGY

**Real Surface:** is the surface limiting the body and separating it from the surrounding surface.

**Geometrical Surface:** is the surface prescribed by the design or by the process of manufacture, neglecting the errors of form and surface roughness.

**Effective Surface:** is the close representation of real surface obtained by instrumental means.

**Surface Texture:** Repetitive or random deviations from the nominal surface which form the pattern of the surface. It includes roughness, waviness, lay and flaws.

**Roughness:** It is caused due to the irregularities in the surface roughness which results from the inherent action of the production process. These include transverse feed marks and the irregularities within them. Roughness spacing is the distance between successive peaks or crests that constitute

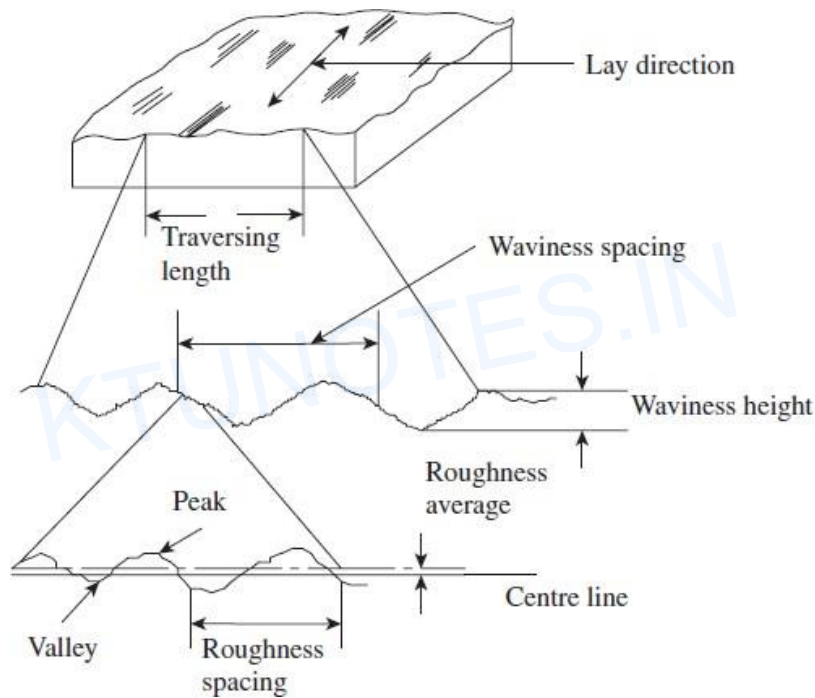
the predominant pattern of roughness. Roughness height is the average deviation measured perpendicular to the centre line.

**Waviness:** It results from the factors such as machine or work deflections, vibrations, chatter, or heat treatment.

**Flaws:** Flaws are irregularities which occur at one place or at relatively infrequent or widely varying intervals in surface (like scratches, cracks, random blemishes, etc.).

**Centre line:** The line about which roughness is measured.

**Lay:** It is the direction of the 'predominant surface pattern' ordinarily determined by the method of production used.



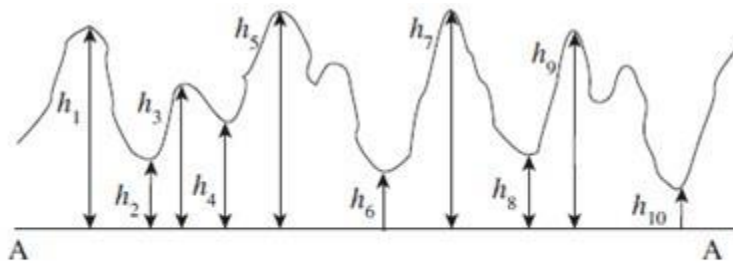
### ANALYSIS OF SURFACE TRACES

It is required to assign a numerical value to surface roughness in order to measure its degree. This will enable the analyst to assess whether the surface quality meets the functional requirements of a component. Some of them are explained below.

#### PEAK-TO-VALLEY HEIGHT ( $R_z$ )

It is the average height enclosing a number of successive peaks and valleys of the roughness.



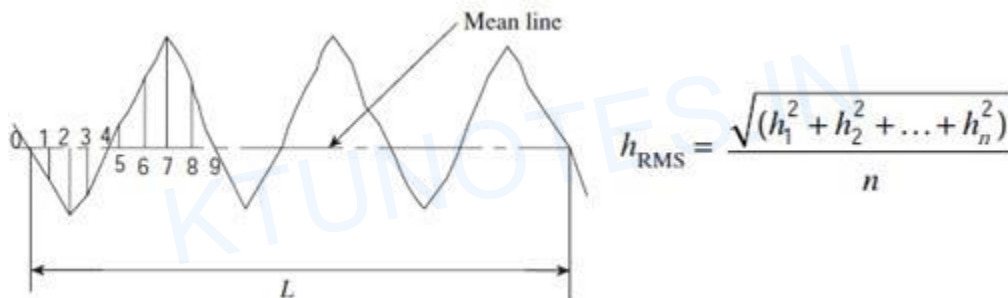


$$R_z = \frac{(h_1 + h_3 + h_5 + h_7 + h_9) - (h_2 + h_4 + h_6 + h_8 + h_{10})}{5} \times \frac{1000}{\text{Vertical magnification}} \mu\text{m}$$

### ROOT MEAN SQUARE VALUE (RMS Value)

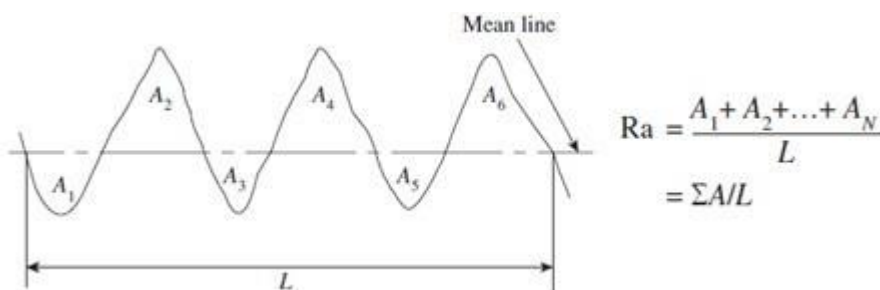
The RMS value is defined as the square root of the mean of squares of the ordinates of the surface measured from a mean line.

If  $h_1, h_2, \dots, h_n$  are equally spaced ordinates at points 1, 2, ...,  $n$ , then



### CENTRE LINE AVERAGE VALUE ( $R_a$ )

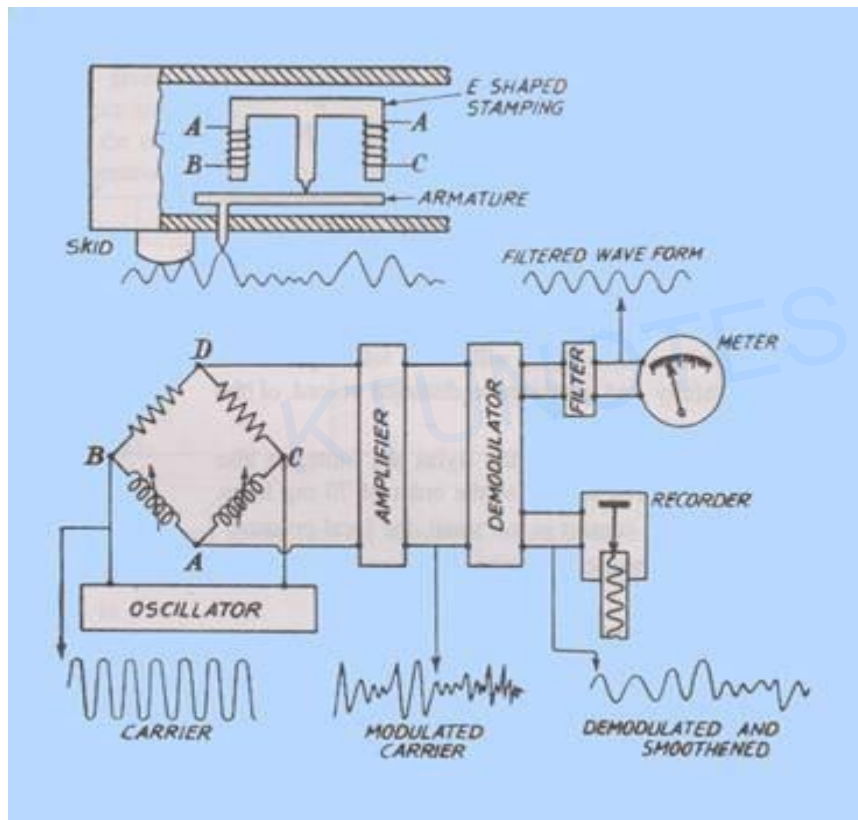
It is defined as the average height from a mean line of all ordinates of the surface, regardless of sign.



### METHODS OF MEASURING SURFACE FINISH

### THE TAYLOR-HOBSON/ TALYSURF INSTRUMENT

The Talysurf is an electronic instrument working on carrier modulating principle. This instrument records the static displacement of the stylus and is dynamic instrument. The measuring head of this instrument consists of a diamond stylus of about 0.002 mm tip radius and skid or shoe which is drawn across the surface by means of a motorised driving unit (gearbox), which provides three motorised speeds giving respectively 20 to 100 horizontal magnifications and a speed suitable for average reading. A neutral position in which the pick-up can be traversed manually is also provided. In this case the arm carrying the stylus forms an armature which pivots about the centre piece of E-shaped stamping as shown in fig. On two legs of (outer pole pieces) the J5-shaped stamping there are coils carrying an a.c. current. These two coils with other two resistances form an oscillator. As the armature is pivoted about the central leg, any movement of the stylus causes the air gap to vary and thus the amplitude of the original a.c. current flowing in the coils is modulated. The output of the bridge thus consists of modulation only as shown in Fig.



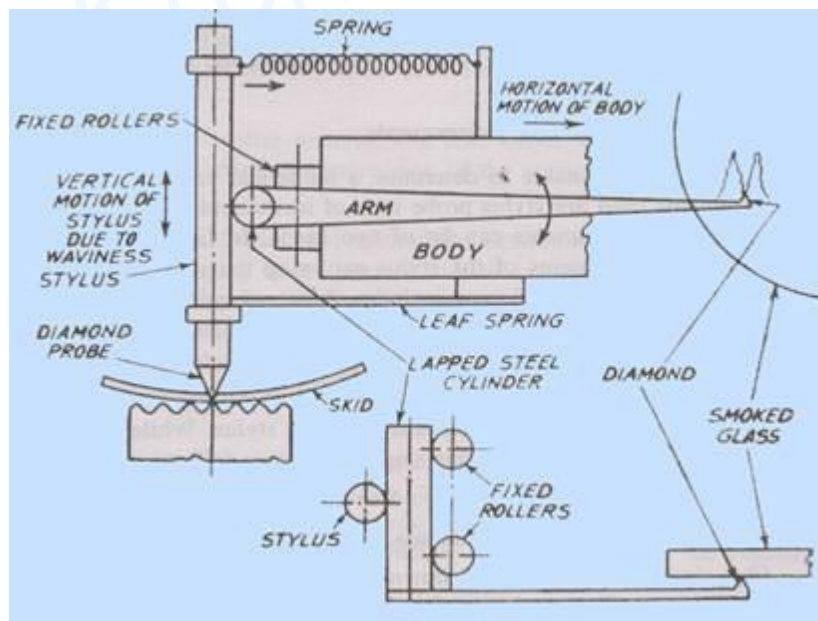
This is further demodulated so that the current now is directly proportional to the vertical displacement of the stylus only. The demodulated output is caused to operate a pen recorder to produce a permanent record and a meter to give a numerical assessment directly. In recorder of this statement the marking medium is an electric discharge through a specially treated paper which blackens at the point of the stylus, so this has no distortion due to drag and the record strictly rectilinear one. Now-a-days microprocessors have made available complete statistical multi-trace systems measuring several places over a given area and can provide standard deviations and average over area-type readings and define complete surface characterisation. These systems lend themselves

to research applications where specialized programming can achieve autocorrelation, power spectrum analysis and peak curvature.

### THE TOMLINSON SURFACE METER

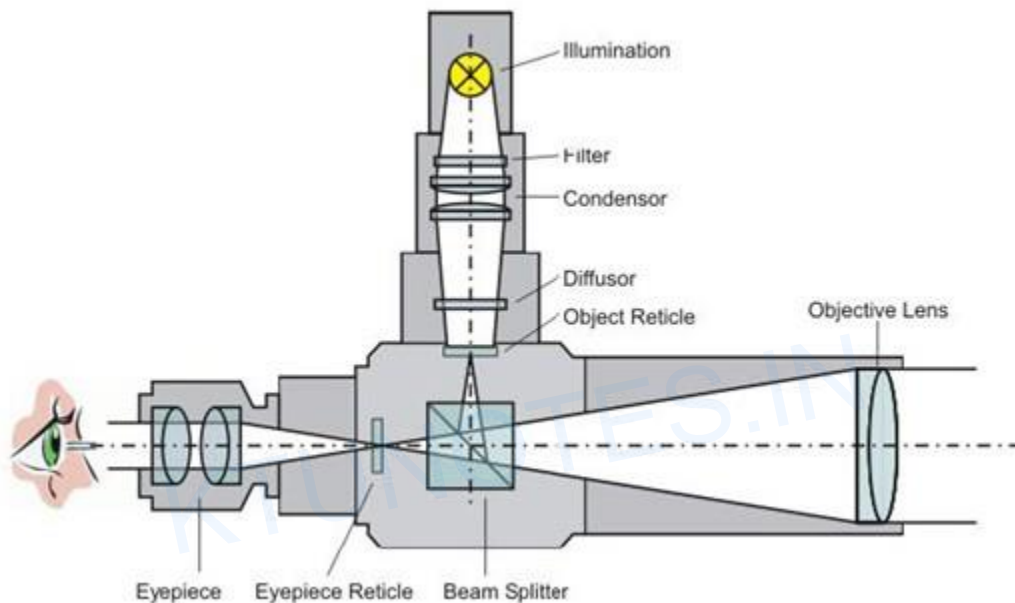
This instrument was designed by Dr. Tomlinson. This instrument uses mechanical-cum-optical means for magnification. The diamond stylus on the surface finish recorder is held by spring pressure against the surface of a lapped steel cylinder. The stylus is also attached to the body of the instrument by a leaf spring and its height is adjustable to enable the diamond to be positioned conveniently. The lapped cylinder is supported on one side by the stylus and on the other side by two fixed rollers as shown in Fig. The stylus is restrained from all motions except the vertical one by the tensions in coil and leaf spring. The tensile forces in these two springs also keep the lapped steel cylinder in position between the stylus and a pair of fixed rollers. A light spring steel arm is attached to the horizontal lapped steel cylinder and it carries at its tip a diamond scribe which bears against a smoked

glass. When measuring surface finish, body is traversed across the surface by a screw rotated by a synchronous motor. Any vertical movement of the stylus caused by the surface irregularities causes the horizontal lapped steel cylinder to roll. By its rolling, the light arm attached to its end provides a magnified movement on a smoked glass plate. This vertical movement coupled with the horizontal movement produces a trace on the glass magnified in vertical direction and there being no magnification in horizontal direction. The smoked glass trace is then, further projected in the order of 50 to 100 magnification for examination. This instrument is comparatively cheap one and gives reliable results.



## AUTOCOLLIMATOR

An autocollimator is an optical instrument for non-contact measurement of angles. They are typically used to align components and measure deflections in optical or mechanical systems. An autocollimator works by projecting an image onto a target mirror, and measuring the deflection of the returned image against a scale, either visually or by means of an electronic detector. A visual autocollimator can measure angles as small as 0.5 second, while an electronic autocollimator can be up to 100 times more accurate.



Visual autocollimators are often used for lining up laser rod ends and checking the face parallelism of optical windows and wedges. Electronic and digital autocollimators are used as angle measurement standards, for monitoring angular movement over long periods of time and for checking angular position repeatability in mechanical systems. Servo autocollimators are specialized compact forms of electronic autocollimators that are used in high speed servo-feedback loops for stable platform applications. An electronic autocollimator will typically be calibrated to read the actual mirror angle.

Autocollimators have straight viewing, a physical beam splitter and infinity adjustment. The autocollimation telescope projects the image of the collimator reticle to infinity. A target mirror, located in the beam path of the autocollimator objective, returns the projected image into the autocollimator and creates an image of the collimator reticle via the beam splitter in the eyepiece reticle plane (autocollimation image). The mechanical (objective tube) axis is adjusted to the optical axis with angle accuracy of  $\pm 30 \mu\text{m} / f$  for autocollimators with  $f \leq 300 \text{ mm}$ . The reticle adjustment amount is  $\pm 10 \mu\text{m}$ .