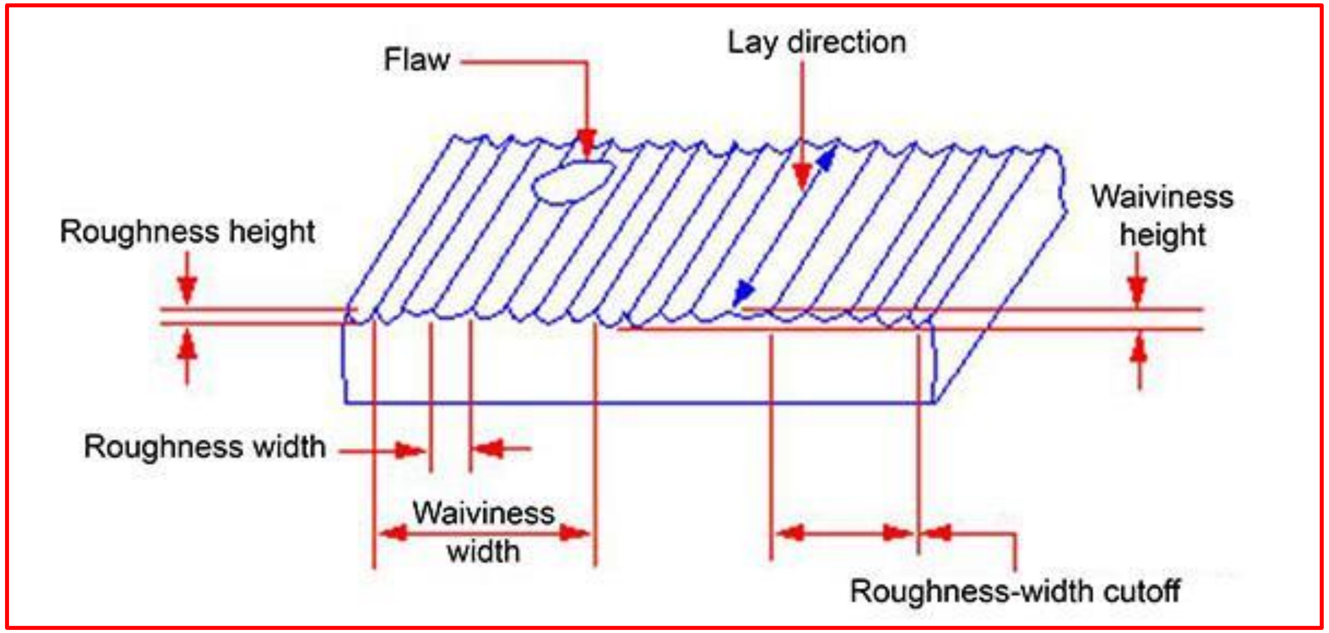
SURFACE TEXTURE AND STYLUS PROBE INSTRUMENT

Surface texture: Introduction to surface finish ,Factors effecting surface finish, Order of geometrical irregularities, elements of surface textures, Evaluation of surface finish

Stylus Probe instrument : Profilometer, Tomlinsion Surface meter ,and Taylor –Hobson Talysurf for surface roughness measurement

Surface texture :

- It has been investigated that the surface texture greatly influences the functioning of the machined parts.
- The properties such as appearance, corrosion resistance, wear resistance, fatigue resistance, lubrication, initial tolerance, ability to hold pressure, load carrying capacity, noise reduction in case of gears are influenced by the surface texture.



- The irregularities on the surface are in the form of succession of hills and valleys varying in **'height and spacing'**. These irregularities are usually termed as surface roughness, surface finish, surface texture or surface quality.
- These irregularities are responsible to a great extent for the appearance of a surface of a component and its suitability for an intended application.

FACTORS AFFECTING SURFACE ROUGHNESS

The following factors affect the surface roughness :

(1) Vibrations

(2) Material of the workpiece

(3) Type of machining

(4) Rigidity of the system consisting of machine tool, fixture cutting tool and work

(5) Type, form, material and sharpness of cutting tool

(6) Cutting conditions i.e., feed, speed and depth of cut

(7) Type of coolant used

Reasons For Controlling Surface Texture

It is seen that different requirements demand different surface texture. For example

- Heat exchanger tubes transfer heat better when their surfaces are slightly rough rather than highly finished.
- Brake drums and clutch plates etc. work best with some degree of surface roughness
- For quieter operations the surfaces should be smooth.

The principal reasons for controlling the surface texture are :

(1) To improve the service life of the components

(2) To improve the fatigue resistance

(3) To reduce initial wear of parts

(4) To have a close dimensional tolerance on the part

(5) To reduce frictional wear

(6)To reduce corrosion by minimising depth of irregularities

(7) for good appearance

Orders of Geometrical irregularities .

As we know that the material machined by chip removal process can't be finished perfectly due to some departures from ideal conditions as specified by the designer :

These geometrical irregularities can be classified into four categories.

1. First Order
2. Second Order
3. Third Order
4. Fourth Order

First Order : The irregularities caused by inaccuracies in the machine tool itself are called as first order irregularities.

(1) irregularities caused due to lack of straightness of guideways on which the tool most moves.

2) Surface irregularities arising due to deformation of work under the action of cutting forces, and

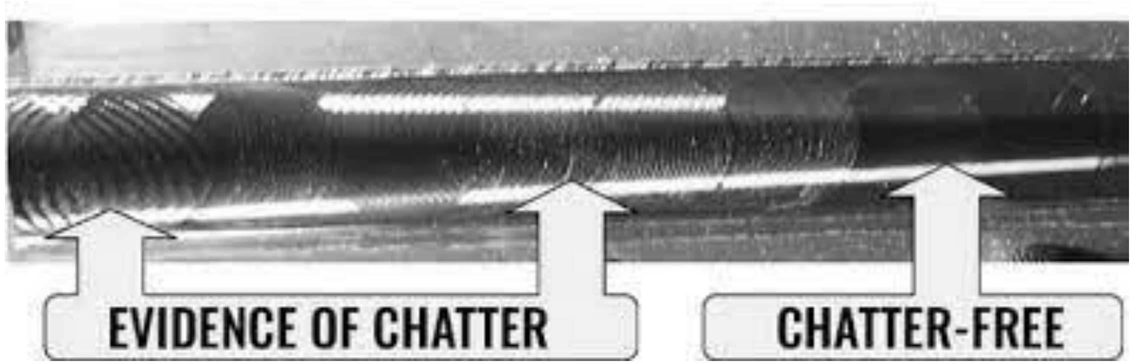
(3) Due to the weight of the material itself.

Second Order. The irregularities caused due to vibrations of any kind are called second order irregularities. These include

Chatter marks on the surface of the parts.

Third Order : Even if the machine were perfect and completely free from vibration some irregularities caused by machining itself due to characteristics of the process This includes

Feed mark of the cutting tool

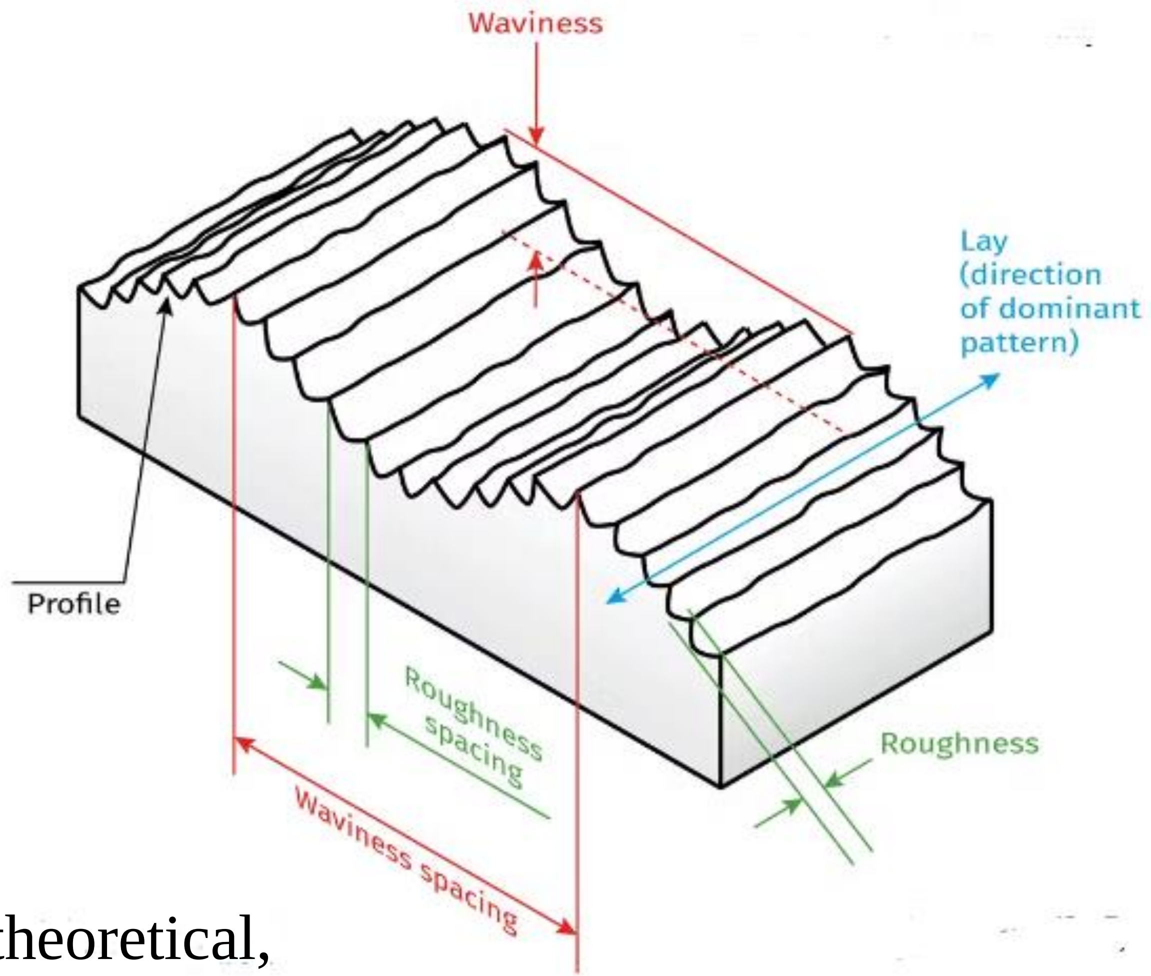


Fourth Order. The fourth order 1rregularities include those arising from the rupture of the material during the separation of the chip

ELEMENTS OF SURFACE TEXTURE

Surface : The surface of a part is confined by the boundary which separates that part from another part, substance or space.

Actual surface : This refers to. the surface of a part which is actually obtained after a. manufacturing process.



Nominal surface: A nominal surface is a theoretical, geometrically perfect surface which does not exist in practice, but it is an average of the irregularities that are superimposed on it.

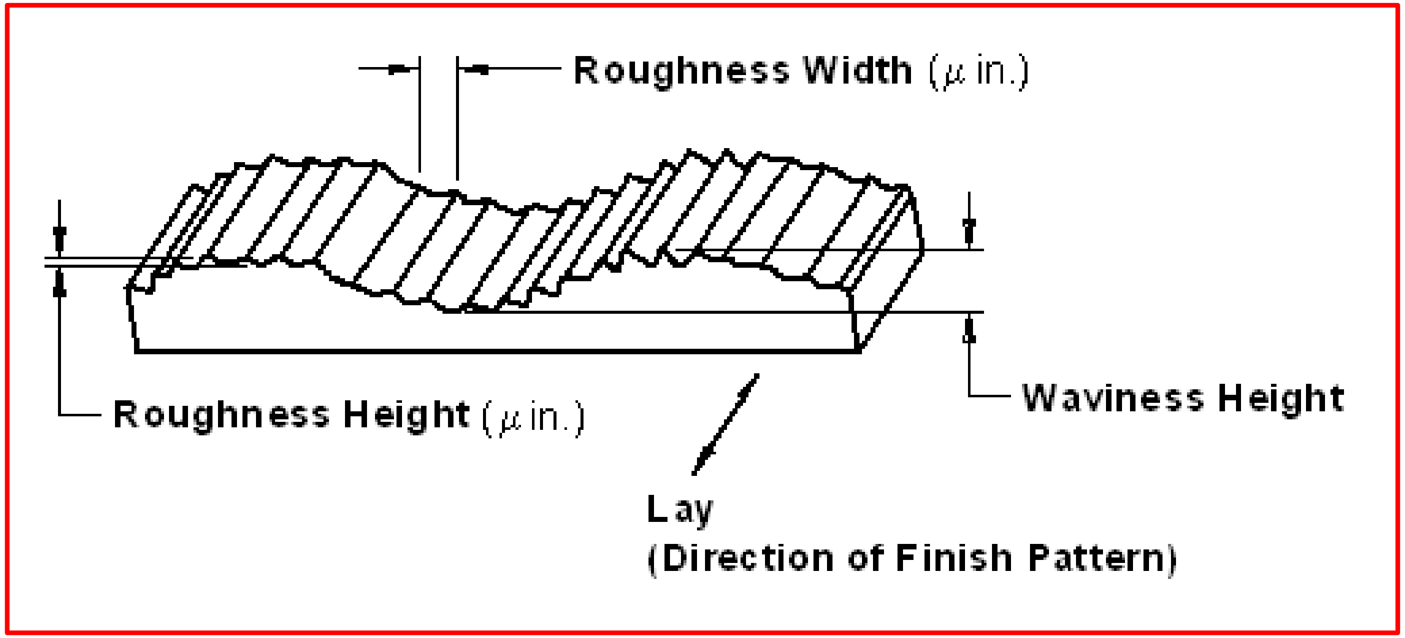
Profile: Profile is defined as the contour of any section through a surface.

Roughness. As already explained roughness refers to relatively finely spaced **micro geometrical irregularities**. It is also called as primary texture and constitutes third and fourth order irregularities.

Roughness Height: This is rated as the arithmetical average deviation expressed in micro-meters normal to an imaginary centre line, running through the roughness profile

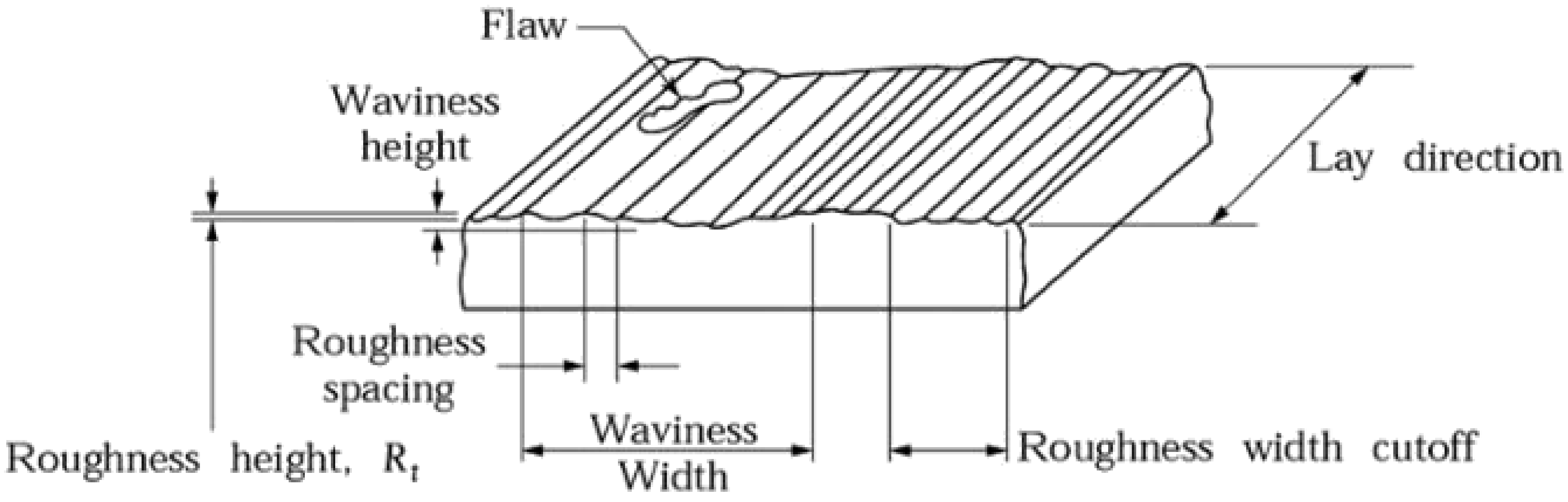
Roughness Width: Roughness width is the distance parallel to-the normal surface between successive peaks or ridges that constitutes the predominant pattern of the roughness.

Roughness Width cutoff: This is the maximum width of surface irregularities that is included in the measurement of roughness height. This is always greater than roughness width and is rated in centimeters



Waviness: Waviness consists of those surface irregularities which are of greater spacing than roughness and it occurs in the form of waves. These are also termed as macro geomatical errors and constitute irregularities of first and second order. These are caused due to misalignment of centers, vibrations, machine or work deflections, warping . etc.

Effective profile: It is the real contour of a surface obtained by using instrument.

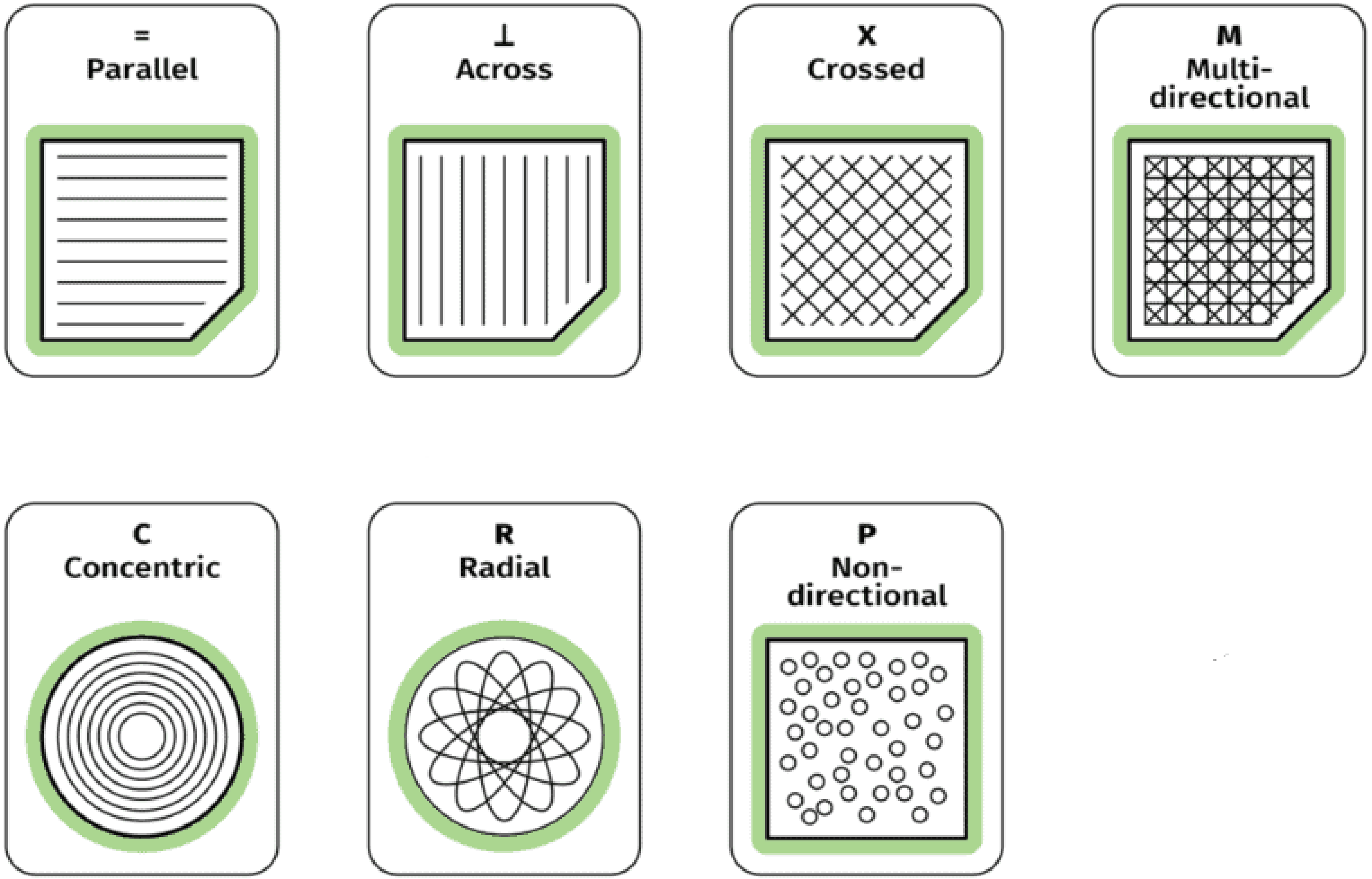


Flaws: Flaws are surface irregularities or imperfections which occur at infrequent intervals and· at random intervals.

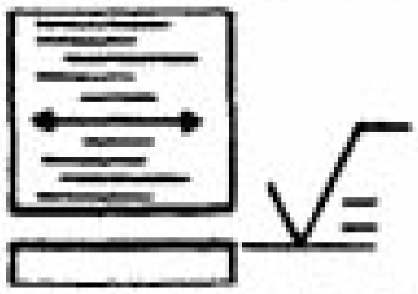
Examples are: scratches, holes, cracks, porosity etc. These may be observed directly with the aid of penetrating dye or other material which makes them visible for examination and evaluation.

Surface Texture: Repetitive· or random deviations from the nominal surface which forms the pattern on the surface. Surface texture includes roughness, waviness, lays and flaws:

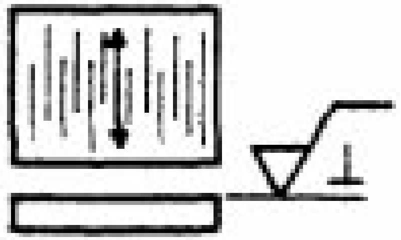
Lay: It is the direction of predominant surface pattern produced by tool marks or scratches. It is determined by the method of production used. Symbols used to indicate. the direction of lay are given below :



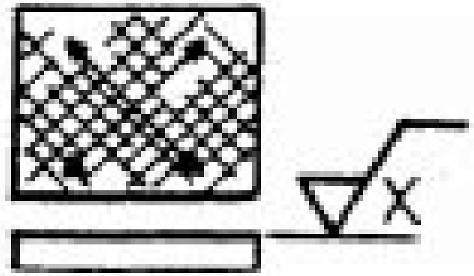
I I = Lay parallel to the boundary line of the nominal surface that is, lay parallel to the line · representing surface to which the symbol is applied e.g., parallel shaping, end view of turning and O.D. grinding



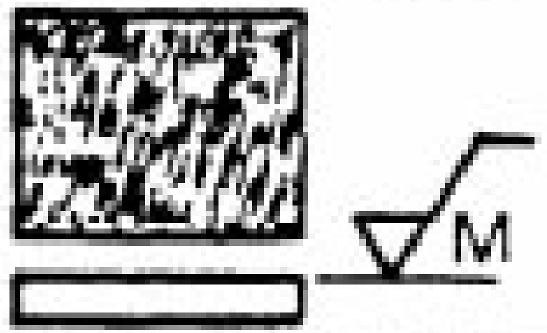
L = Lay perpendicular to the boundary line of the nominal surface, that is lay perpendicular to the line representing surface to which the symbol is applied, e.g., end view of shaping, longitudinal view of turning and O.D. grinding.



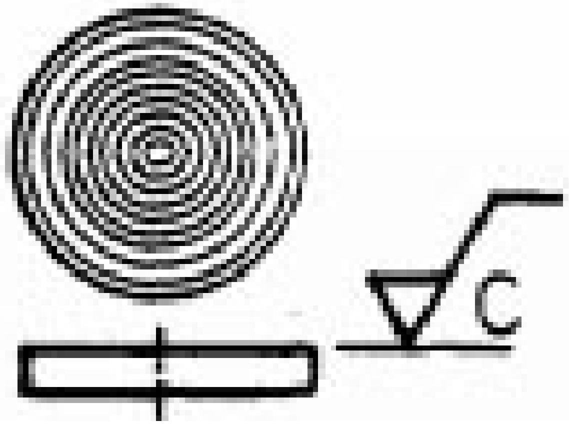
X = lay angular in both directions to the line representing the surface. to which symbol is applied, e.g., traversed end mill, side wheel grinding.



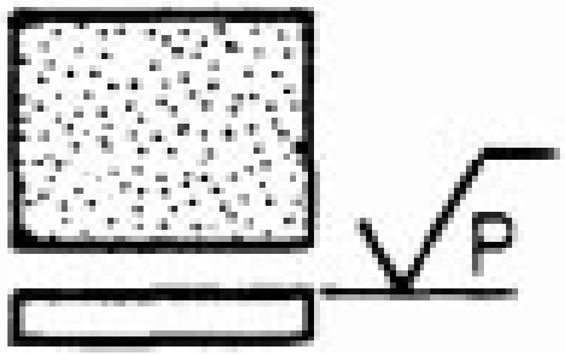
M = Lay multidirectional e.g. lapping, super finishing, honing.



C = Lay approximately circular relative to the centre of the surface to which the symbol is applied e.g., facing. on a lathe.



R = Lay approximately radial relative to the centre of the surface to which the symbol is applied, e.g., surface ground on a turntable, fly cut and indexed on end mill.



EVALUATION OF SURFACE FINISH

A numerical assessment of surface finish can be carried out in a number of ways. These numerical values are obtained with respect to a datum. In practice, the following three methods of evaluating primary texture (roughness) of a surface are used

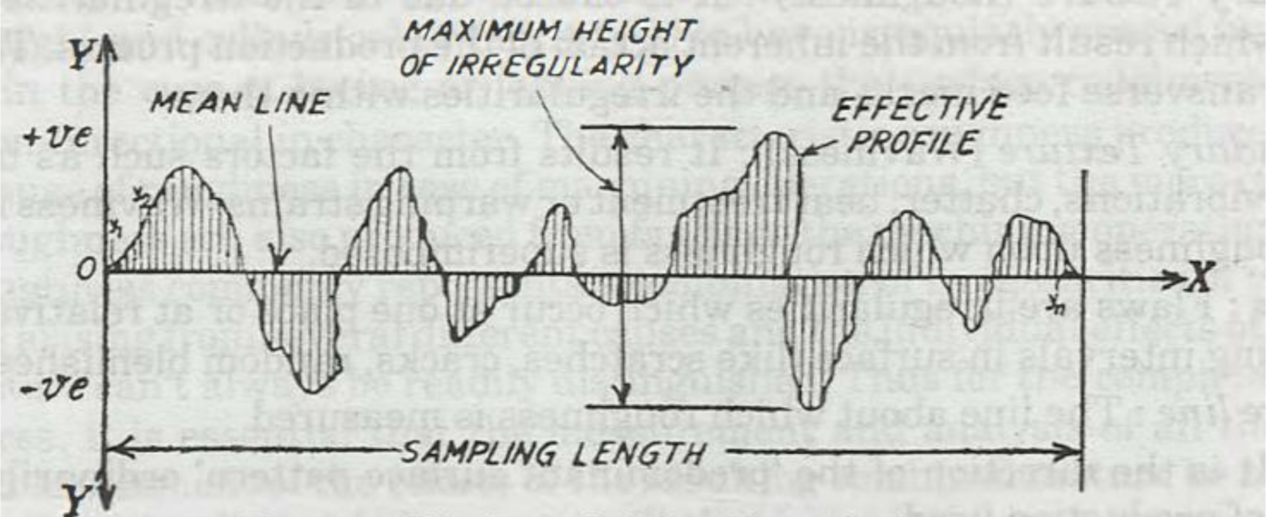
(1) Peak to valley height method

(2) The average roughness

(3) Form factor or bearing curve.

(1) Peak to valley height method

- This method is largely used in Germany and Russia. It measures the maximum depth of the surface irregularities over a given sample length, and largest value of the depth is accepted as a measure of roughness.



- The drawback of this method is that it may read the same h_{max} for two largely different texture.

- The value obtained would not give a representative assessment of the surface.

- To overcome this PV (Peak to Valley) height is defined as the distance between a pair of lines running parallel to the general 'lay' of the trace positioned so that the length lying within the peaks at the top is 5% of the trace length, and that within the valleys at the bottom is 10% of the trace length. This is represented graphically in Figure

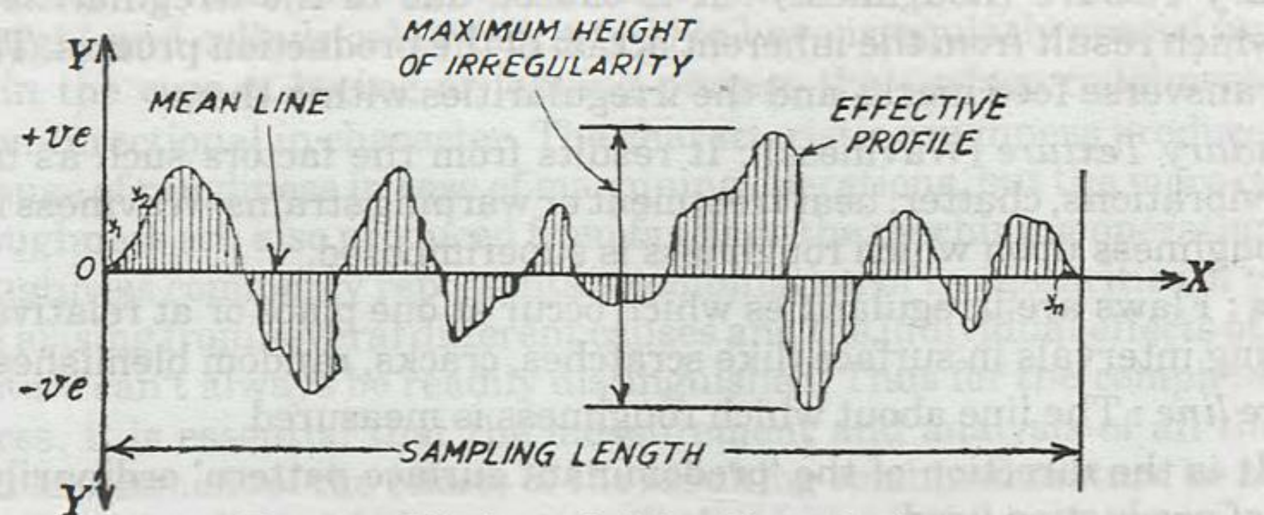
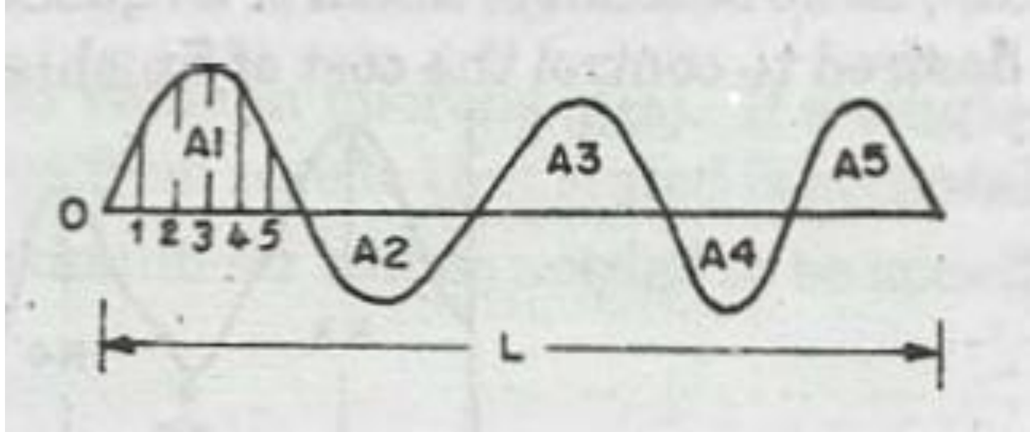


Fig. 11.4. Maximum height of irregularity.

Average Roughness: For assessment of average roughness the following three statistical criteria are used



(a) C.L.A.Method : In this method, the surface roughness is measured as the average deviation from the nominal surface. Centre Line Average or Arithmetic Average is defined as the average values of the ordinates from the mean line, regardless of the arithmetic signs of the ordinates.

$$\text{C.L.A Value} = \frac{h_1 + h_2 + h_3 + \ldots\ldots h_n}{n}$$

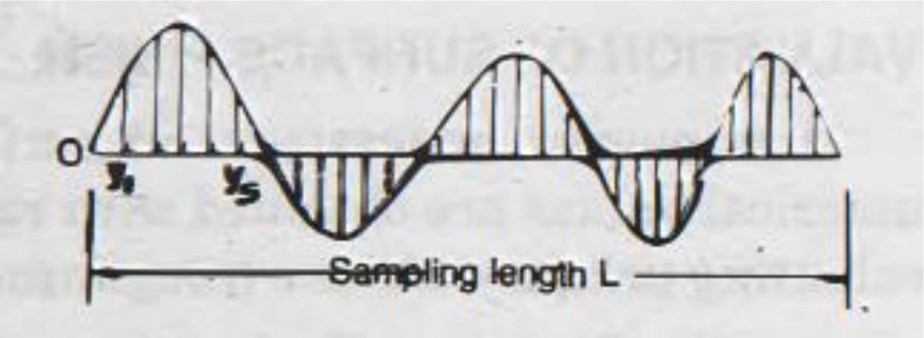
$$\text{C.L.A.} = \frac{A_1 + A_2 + A_3 + \ldots\ldots A_n}{L}$$

$$= \frac{\Sigma A}{L}$$

CLA value measure is preferred to **RMS** value measure because its value can be easily determined by measuring the areas with, planimeter or graph or can be readily determined in electrical instruments by integrating the,, movement of the styles and displaying the result as an average.

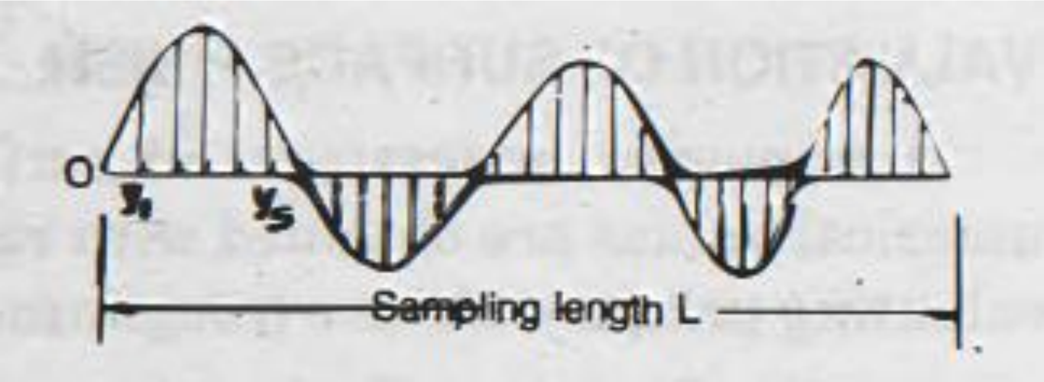
(b) R.M.S. Method:

In this method also, the roughness is measured as the average deviation from the nominal surface. Root mean square value measured is based on the least squares.



R.M.S value is defined as the square root of the arithmetic mean of the values of the squares of the ordinates of the surface measured from a mean line. It is obtained by setting many equidistant ordinates on the mean line (y1 , y2 , y3 , •••) and then taking the root of the mean of the squared ordinates.

Let us assume that the sample length 'L' is divided into 'n' equal parts and y1 , y2 , Y3, ···Yn are the heights of the ordinates erected at those points.

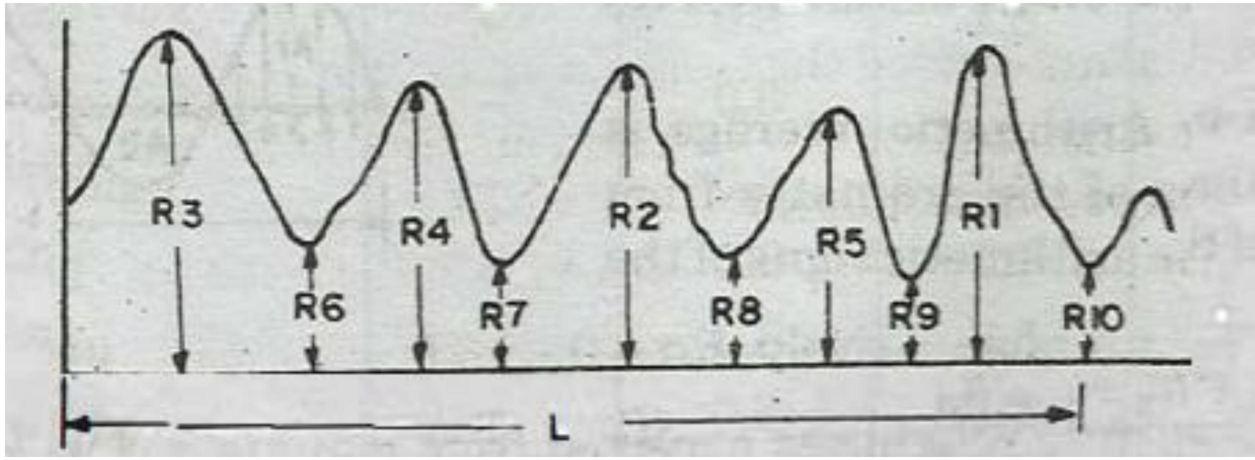


Then, RMS average $= \sqrt{\dfrac{y_1^2 + y_2^2 + y_3^2 + \ldots + y_n^2}{n}}$

$$y_{rms} = \left(\frac{1}{L} \int_0^L y^2 \, dL \right)^{1/2}$$

(c) Ten Point Height Method :

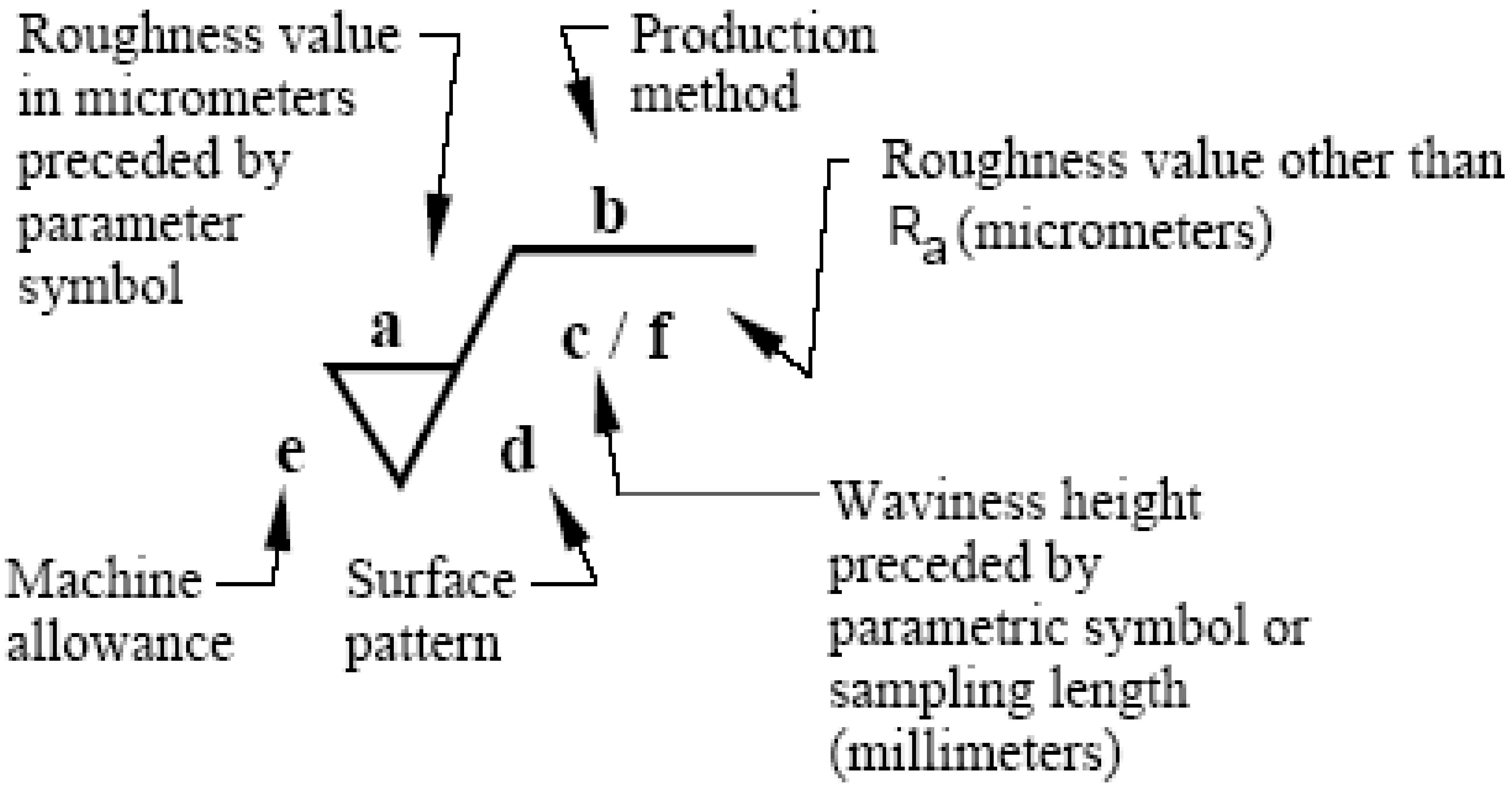
In this method, the aver-age difference between the five highest peaks and five lowest valleys of surface texture within the sampling length, measured from a line parallel to the mean line and not crossing the profile is used to denote the amount of surface roughness. Mathematically,



R_2 = ten point height of irregularities

$$= \frac{1}{5}[(R_1 + R_2 + R_3 + R_4 + R_5) - (R_6 + R_7 + R_8 + R_9 + R_{10})]$$

- This method is relatively simple method of analysis and measures the total depth of surface irregularities within the sampling length. But it does not give sufficient information about the surface, as no account is taken of frequency of the irregularities and the profile shape.
- It is used when it is desired to control the cost of finishing for checking the rough machining.


Roughness value in micrometers preceded by parameter symbol
Production method
Roughness value other than R_a (micrometers)
b
a
c / f
e
d
Waviness height preceded by parametric symbol or sampling length (millimeters)
Machine allowance
Surface pattern

1. Stylus probe instruments.

There are two types of stylus instruments: True datum and surface datum, which are also known as skidless and skid type, respectively.

- **In the skidless instrument**, the stylus is drawn across the surface by a mechanical movement that results in a precise path. The path is the datum from which the assessment is made.
- **In the skid-type instrument,** the stylus pickup unit is supported by a member that rests on the surface and slides along with it. This additional member is the skid or the shoe.

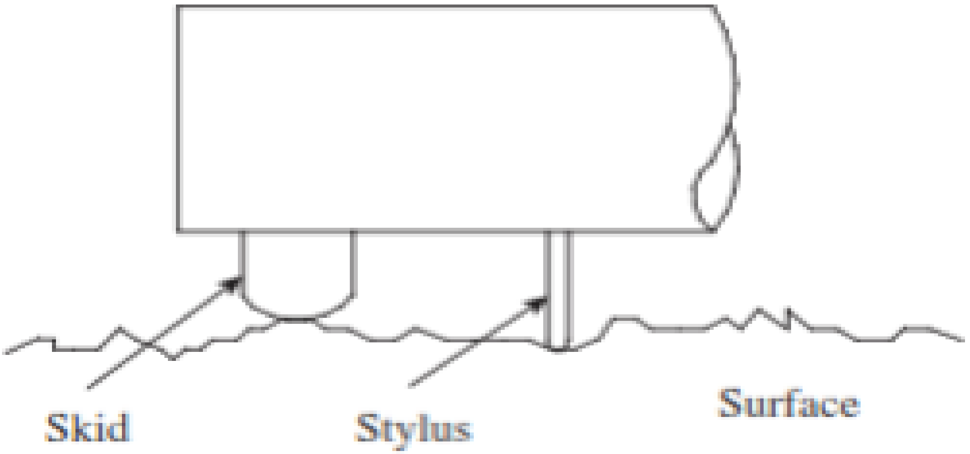
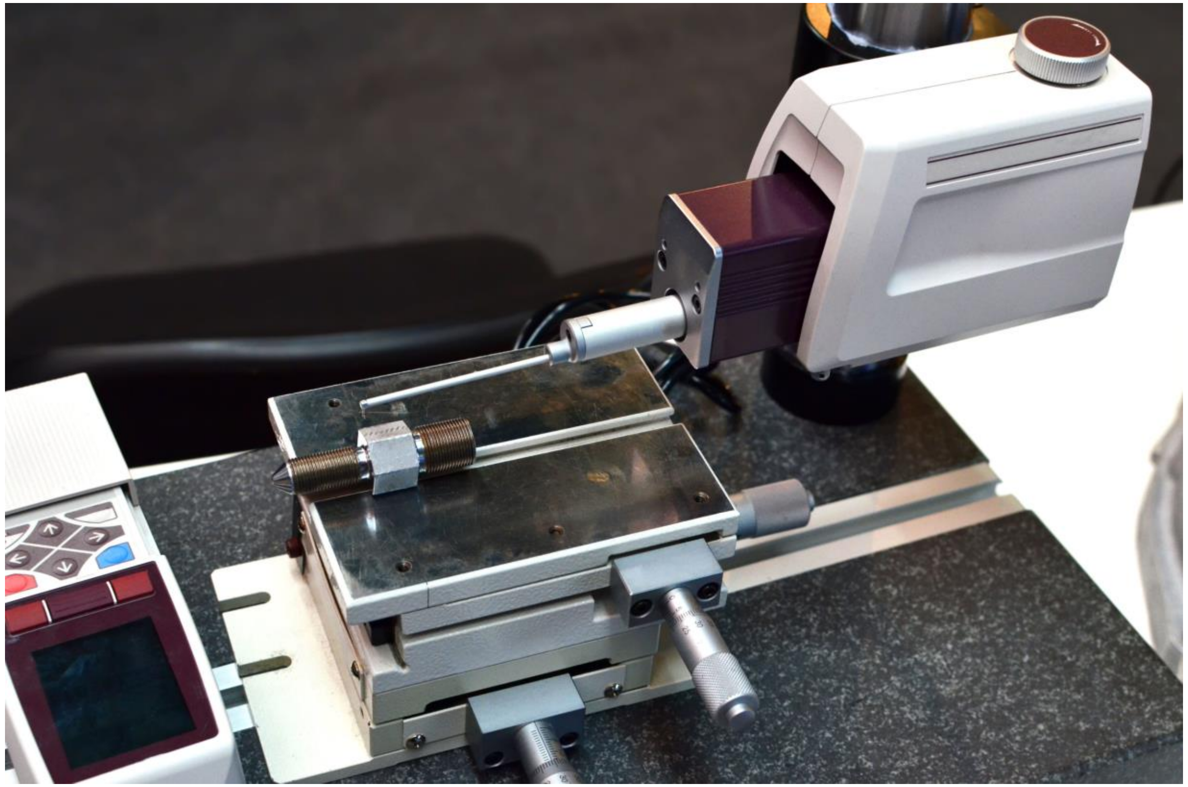


Fig. 4.38 Skid and stylus type

The stylus is typically a diamond having a cone angle of **90°** and a spherical tip radius of 1–5 μm or even less. The stylus tip radius should be small enough to follow the details of the surface irregularities, but should also have the strength to resist wear and shocks. Stylus load should also be controlled so that it does not leave additional scratch marks on the component being inspected.

Profilometer.

A profilometer is a compact device that can be used for the direct measurement of surface texture. A finely pointed stylus will be in contact with the workpiece surface. An electrical pickup attached to the stylus amplifies the signal and feeds it to either an indicating unit or a recording unit. The stylus may be moved either by hand or by a motorized mechanism.



The profilometer is capable of measuring roughness together with waviness and any other surface flaws. It provides a quick-fix means of conducting an initial investigation before attempting a major investigation of surface quality.

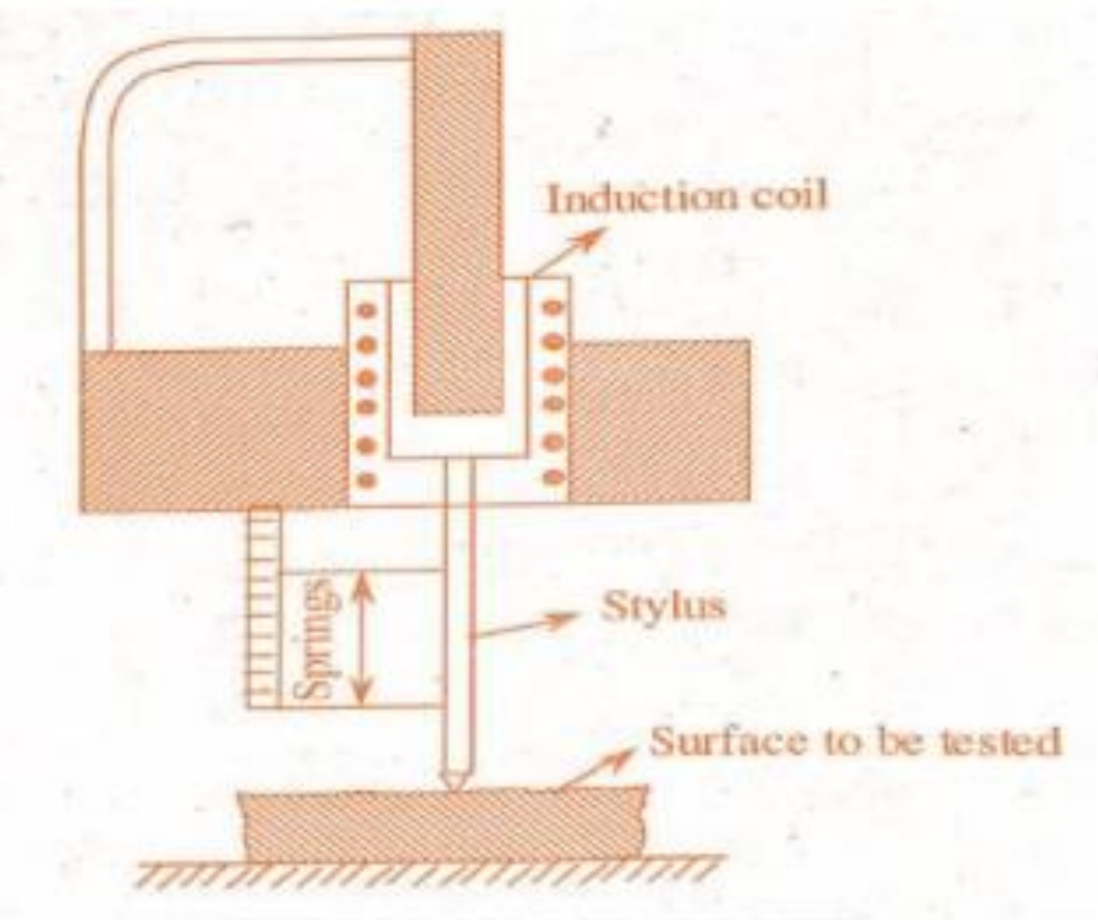


Fig. 4.42 Profilometer

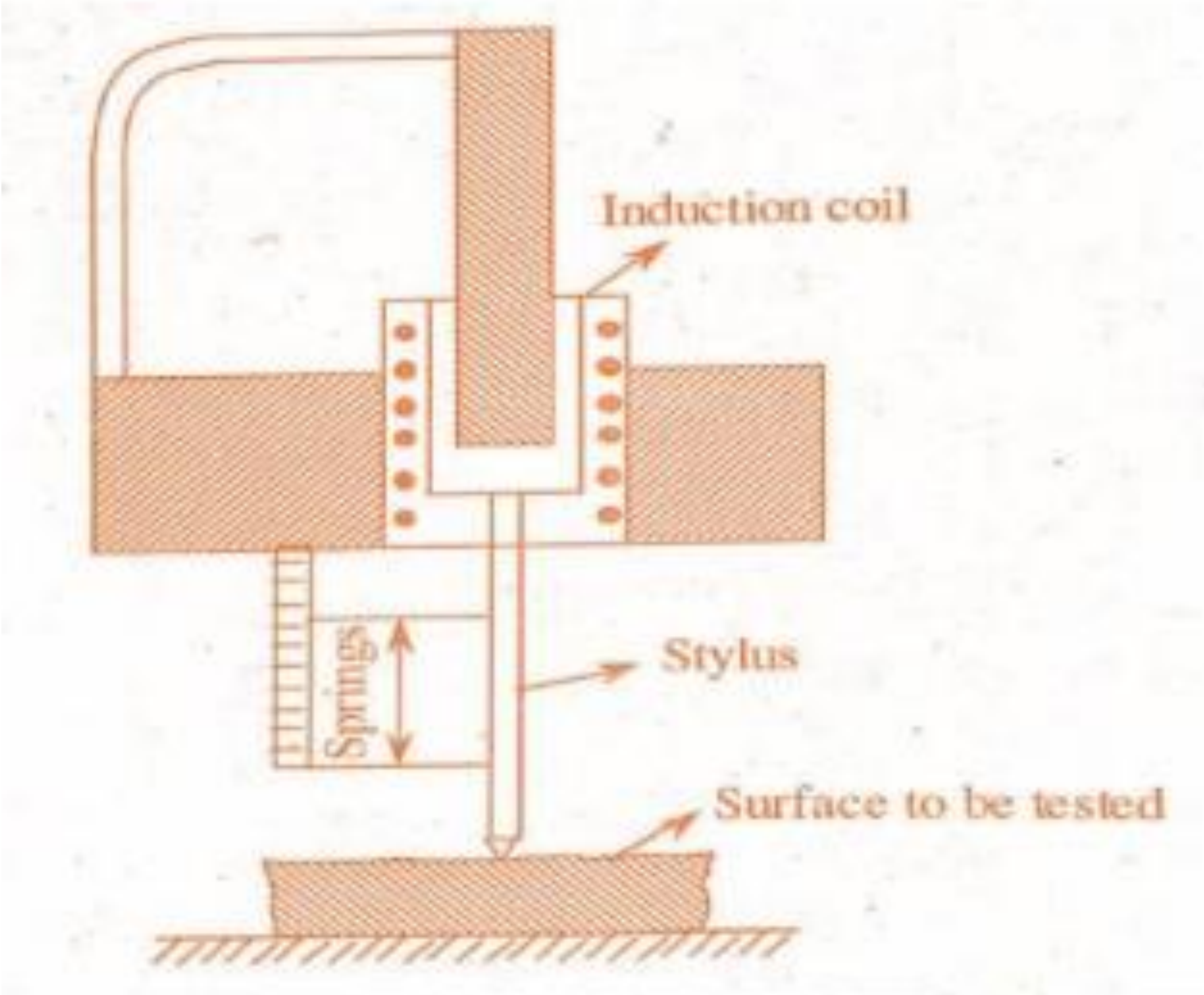
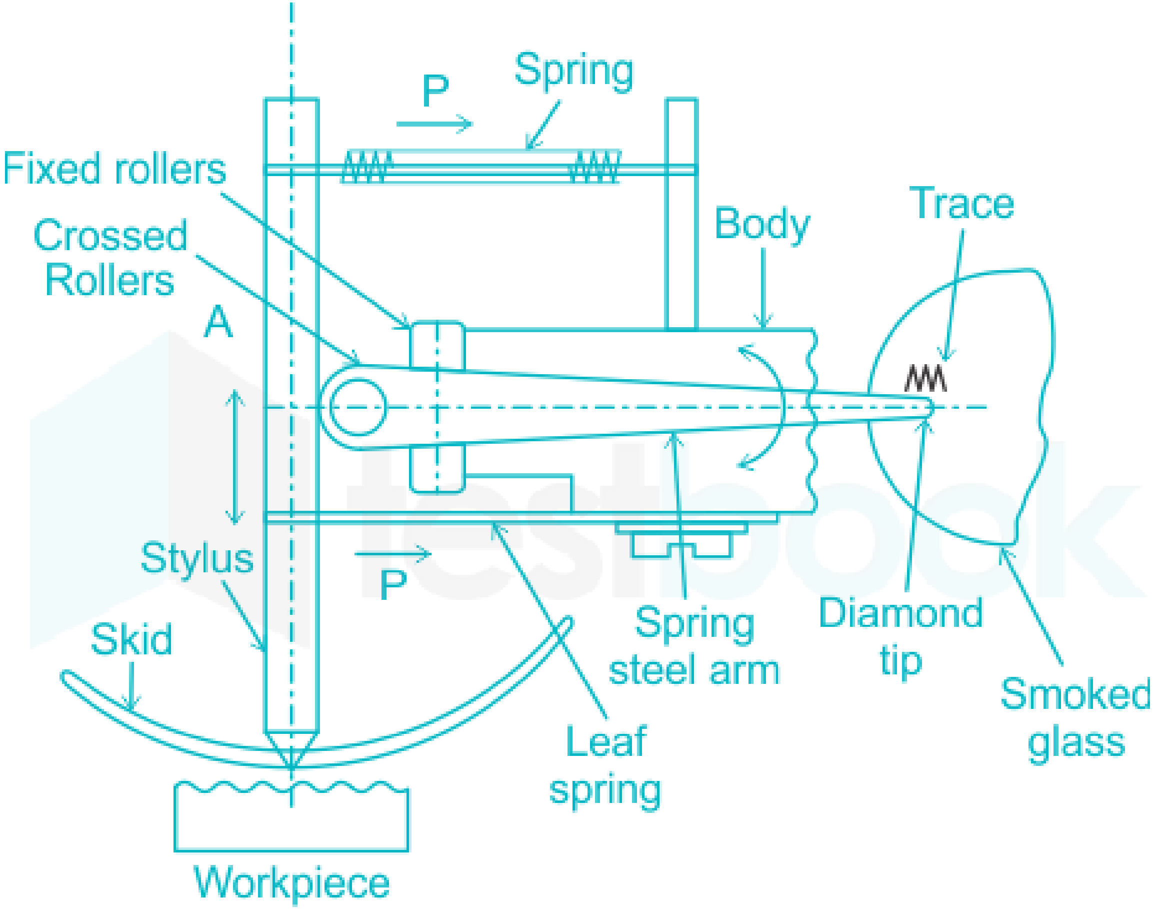


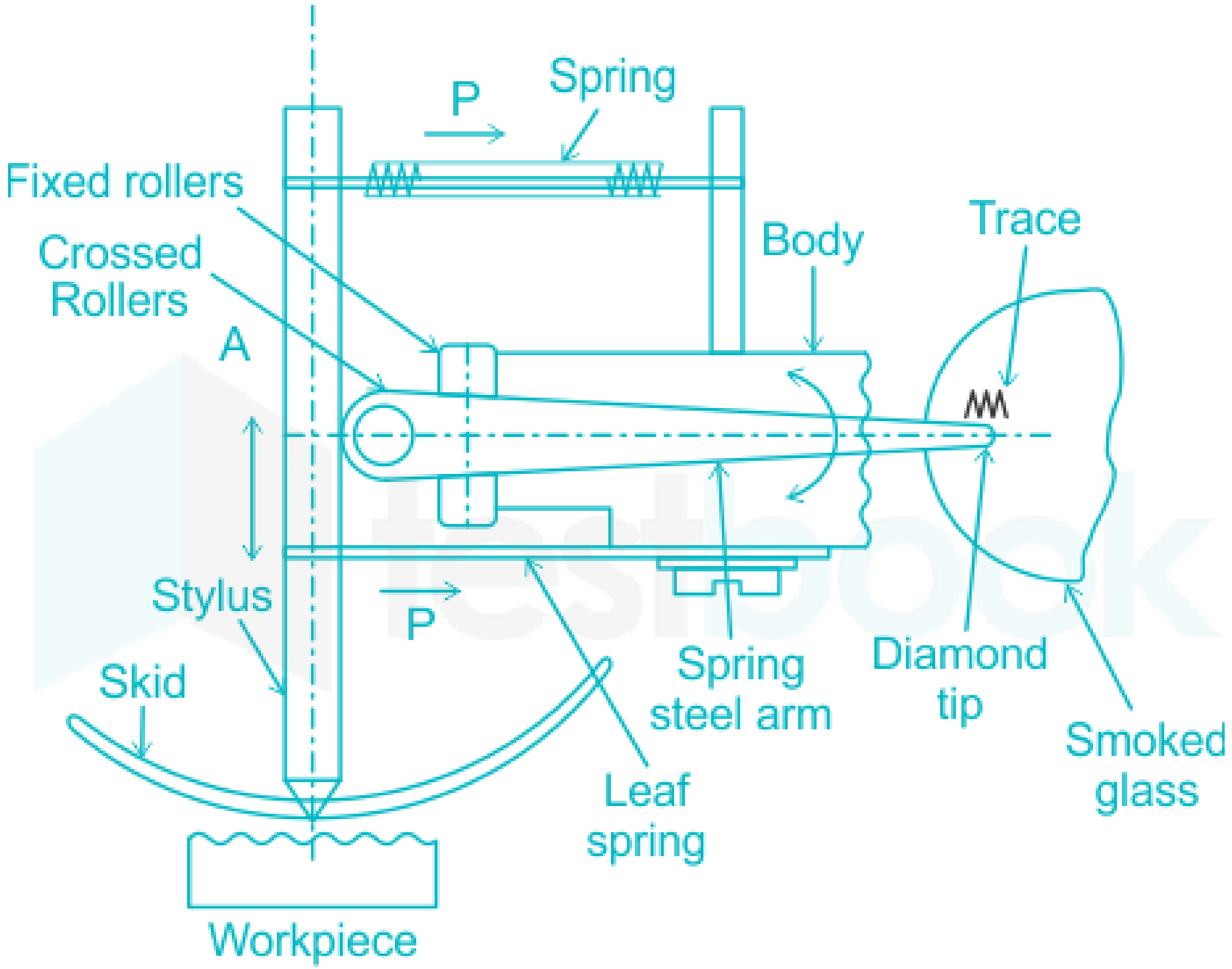
Fig. 4.42 Profilometer

Tomlinson Surface Meter

- The sensing element is the stylus, which moves up and down depending on the irregularities of the workpiece surface.
- The stylus is constrained to move only in the vertical direction because of a leaf spring and a coil spring.
- The tension in the coil spring P causes a similar tension in the leaf spring.



Tomlinson surface meter



Tomlinson surface meter

- These two combined forces hold a cross roller in position between the stylus and a pair of parallel fixed rollers.
- A shoe is attached to the body of the instrument to provide the required datum for the measurement of surface roughness.
- A light spring steel arm is P Spring attached to the cross-roller and carries a diamond tip.

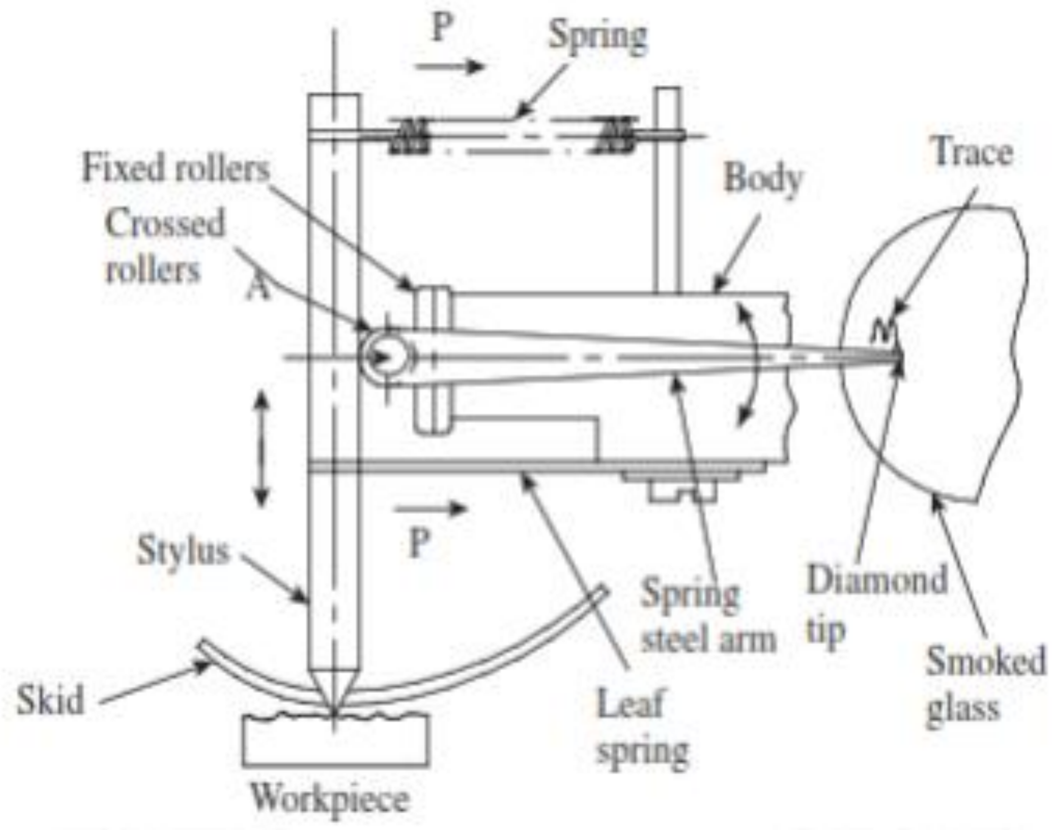
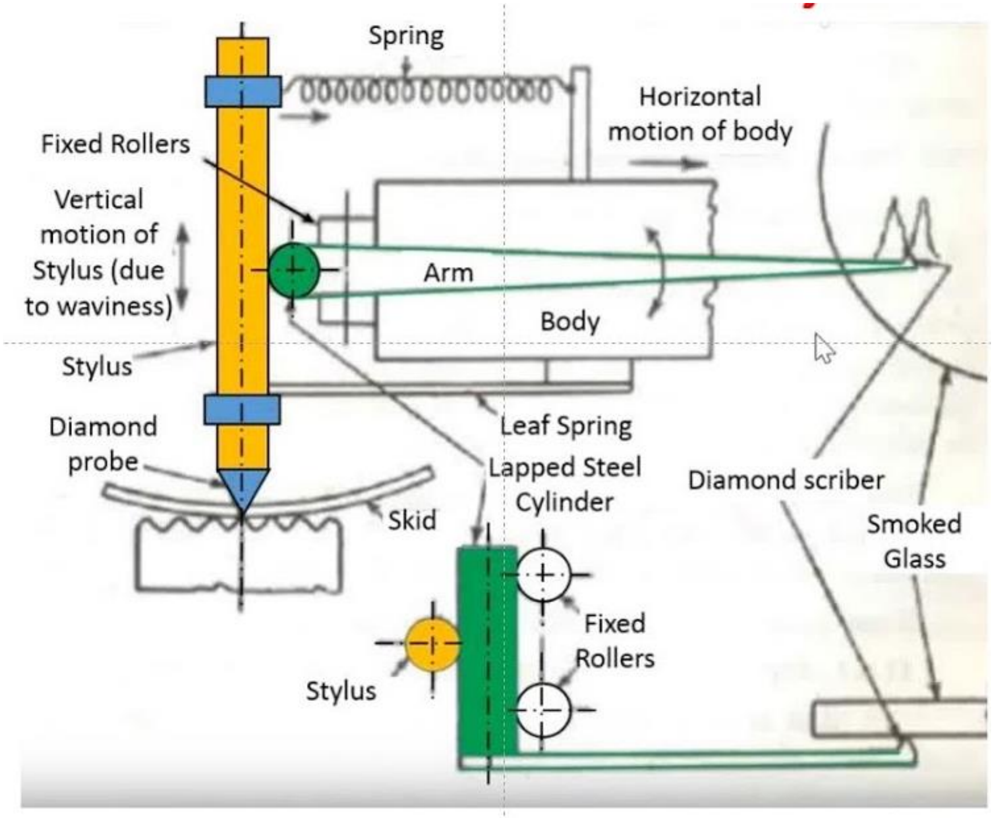


Fig. 4.39 Tomlinson surface meter

- The translatory motion of the stylus causes rotation of the cross roller about the point A, which in turn is converted to a magnified motion of the diamond point
- The diamond tip traces the profile of the workpiece on a smoked glass sheet. The glass sheet is transferred to an optical projector and magnified further. Typically, a magnification of the order of 50–100 is easily achieved in this instrument.



- In order to get a trace of the surface irregularities, a relative motion needs to be generated between the stylus and the workpiece surface
- Usually, this requirement is met by moving the body of the instrument slowly with a screw driven by an electric motor at a very slow speed
- Anti-friction guide-ways are used to provide friction-free movement in a straight path.

3.Taylor–Hobson Talysurf

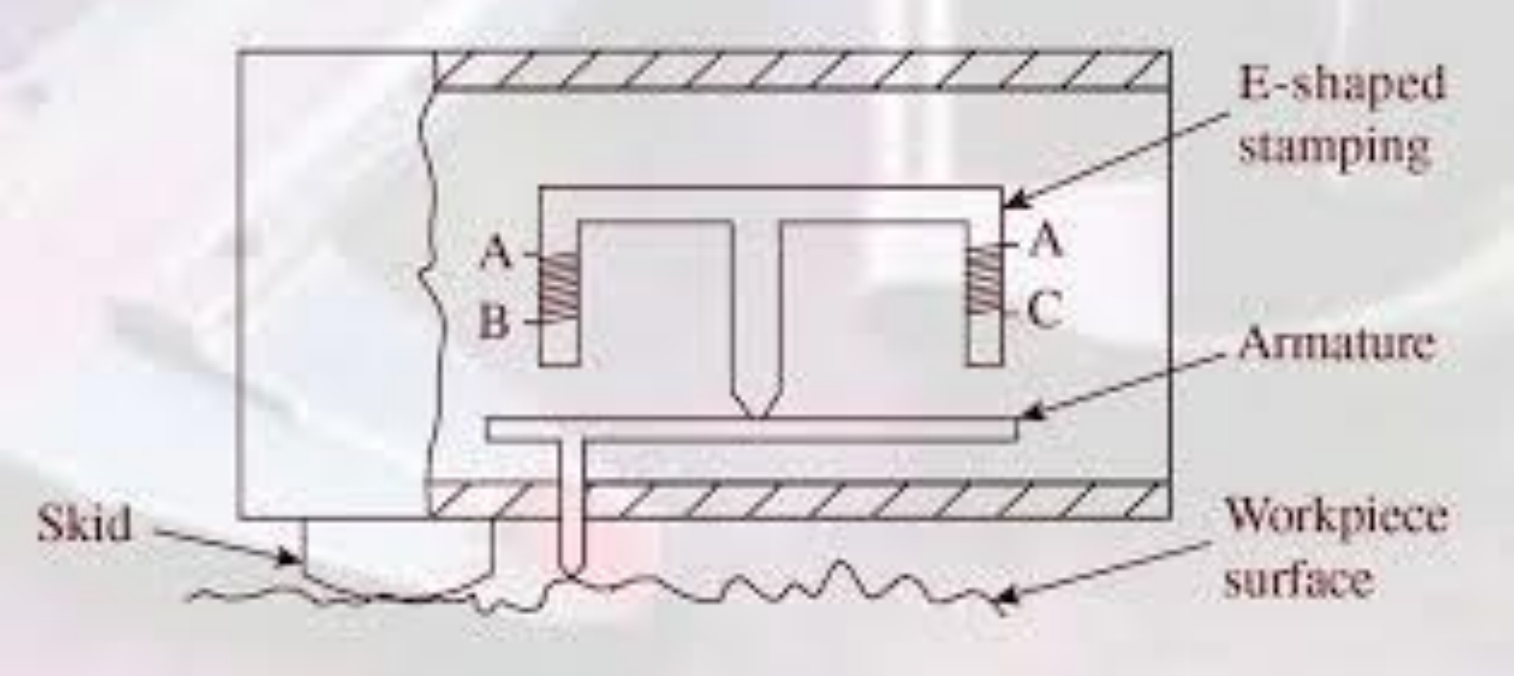


Fig. 9.10 Taylor–Hobson talysurf

The Taylor–Hobson talysurf works on the same principle as that of the Tomlinson surface meter. However, unlike the surface meter, which is purely a mechanical instrument, the talysurf is an electronic instrument. This factor makes the talysurf a more versatile instrument and can be used in any condition, be it a metrology laboratory or the factory shop floor.

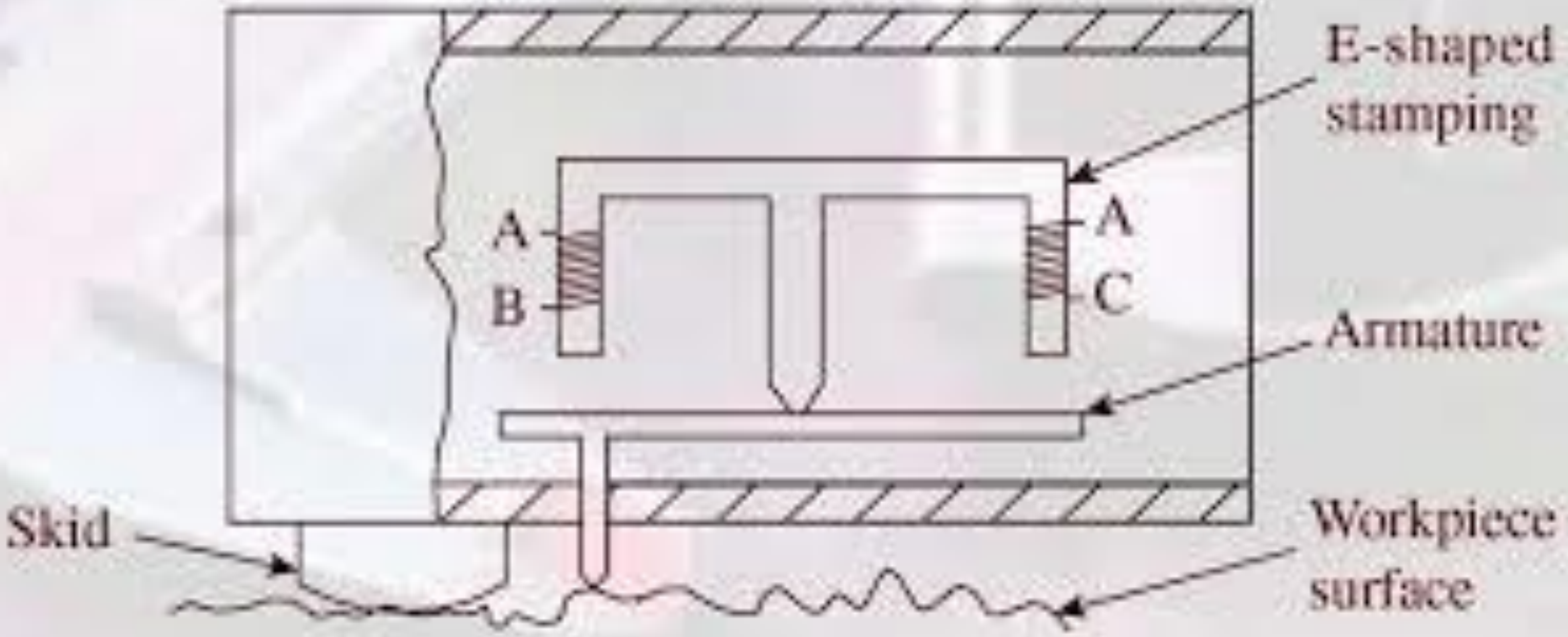


Fig. 9.10 Taylor–Hobson talysurf

- The stylus is attached to an armature, which pivots about the centre of piece of an E-shaped stamping.
- The outer legs of the E-shaped stamping are wound with electrical coils.
- A predetermined value of alternating current (excitation current) is supplied to the coils. The coils form part of a bridge circuit.
- A skid or shoe provides the datum to plot surface roughness. The measuring head can be traversed in a linear path by an electric motor.
- The motor, which may be of a variable speed type or provided with a gear box, provides the required speed for the movement of the measuring head.

As the stylus moves up and down due to surface irregularities, the armature is also displaced. This causes variation in the air gap, leading to an imbalance in the bridge circuit. The resulting bridge circuit output consists of only modulation. This is fed to an amplifier and a pen recorder is used to make a permanent record. The instrument has the capability to calculate and display the roughness value according to a standard formula.

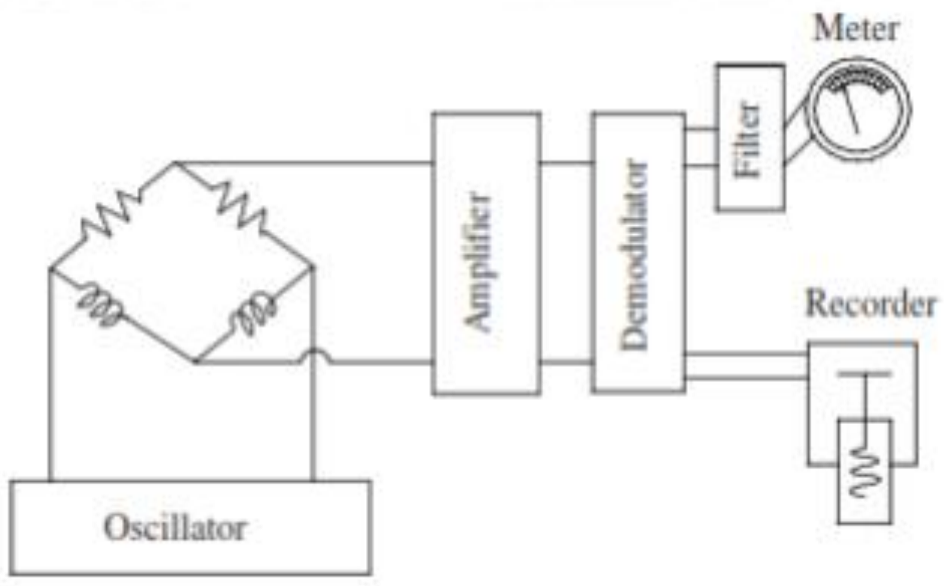


Fig. 4.41 Bridge circuit and electronics