# UNIT – 3:
# Comparators and Angular measurement

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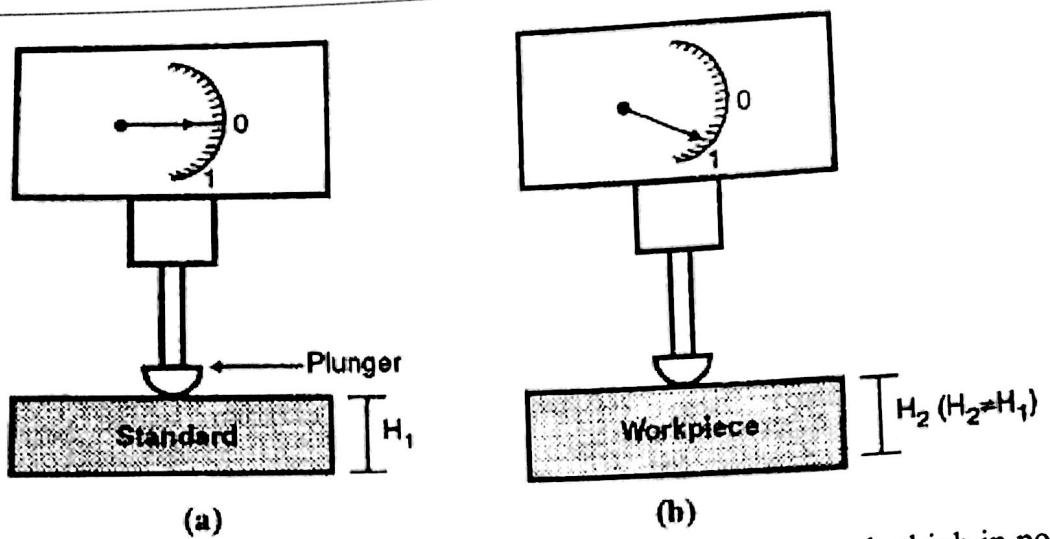
Comparators can give precision measurements, with consistent accuracy by eliminating human error. They are employed to find out, by how much the dimensions of the given component differ from that of a known datum. If the indicated difference is small, a suitable magnification device is selected to obtain the desired accuracy of measurements. It is an indirect type of instrument and used for linear measurement. If the dimension is less or greater, than the standard, then the difference will be shown on the dial. It gives only the difference between actual and standard dimension of the workpiece. To check the height of the job H2 ,with the standard job of height H1




(a) (b)

Initially, the comparator is adjusted to zero on its dial with a standard job in position as shown in Figure(a). The reading H1is taken with the help of a plunger. Then the standard job is replaced by the work-piece to be checked and the reading H2 is taken. If H1and H2 are different, then the change i~ the dimension will be shown on the dial of the comparator. Thus difference is then magnified 1000 to 3000 X to get the clear variation in the standard and actual job.

In short, Comparator is a device which
(1) Picks up small variations in dimensions.
(2) Magnifies it.
(3) Displays it by using indicating devices, by which comparison can be made with some standard value.

**Classifieation:**

1. Mechanical Comparator: It works on gears pinions, linkages, levers, springs etc.
2. Pneumatic Comparator: Pneumatic comparator works by using high pressure air, valves, back pressure etc.
3. Optical Comparator: Optical comparator works by using lens, mirrors, light source etc.
4. Electrical Comparator: Works by using step up, step down transformers.
5. Electronic Comparator: It works by using amplifier, digital signal etc.
6. Combined Comparator: The combination of any two of the above types can give the best result.

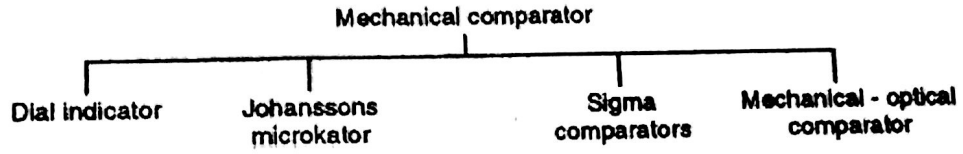
**Characteristics of Good Comparators:**

1. It should be compact.
2. It should be easy to handle.
3. It should give quick response or quick result.
4. It should be reliable, while in use.
5. There should be no effects of environment on the comparator.
6. Its weight must be less.
7. It must be cheaper.
8. It must be easily available in the market.
9. It should be sensitive as per the requirement.
10. The design should be robust.
11. It should be linear in scale so that it is easy to read and get uniform response.

12. It should have less maintenance.
13. It should have hard contact point, with long life.
14. It should be free from backlash and wear.

**Mechanical Comparator:**

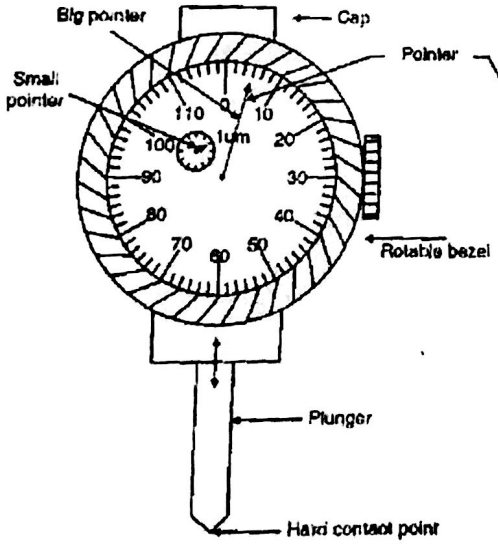
It is self controlled and no power or any other form of energy is required. It employs mechanical means for magnifying the small movement of the measuring stylus. The movement is due to the difference between the standard and the actual dimension being checked



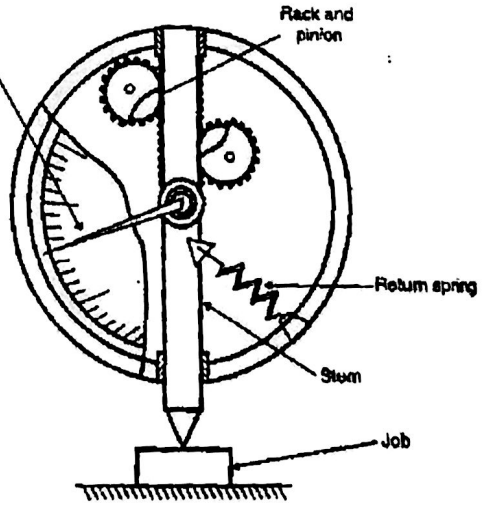

The method for magnifying the small stylus movement in all the mechanical comparators is by means of levers, gear trains or combination of these. They are available of different make and each has it's own characteristic. The various types of mechanical comparators are dial indicator, rack and pinion, sigma comparator, Johansson mikrokator.

**a. Dial Indicator:**

It operates on the principle, that a very slight upward pressure on the spindle at the contact point is multiplied through a system of gears and levers. It is indicated on the face of the dial by a dial finger. Dial indicators basically consists of a body with a round graduated dial and a contact point connected with a spiral or gear train so that hand on the dial face indicates the amount of movement of the contact point. They are designed for use on a wide range of standard measuring devices such as dial box gauges, portal dial, hand gauges, dial depth gauges, diameter gauges and dial indicator snap gauge.




(a) Dial indicator




(b) Mechanism of dial indicator

Corresponds to a spindle movement of 1 mm. The movement mechanism of the instrument is housed in a metal case for it's protection. The large dial scale is graduated into 100 divisions. The indicator is set to zero by the use of slip gauges representing the basic size of part.

**Requirements of Good Dial Indicator:**

1. It should give trouble free and dependable readings over a long period.
2. The pressure required on measuring head to obtain zero reading must remain constant over the whole range.
3. The pointer should indicate the direction of movement of the measuring plunger.
4. The accuracy of the readings should be within close limits of the various sizes and ranges
5. The movement of the measuring plunger should be in either direction without affecting the accuracy.
6. The pointer movement should be damped, so that it will not oscillate when the readings are being taken.

**Applications:**

1. Comparing two heights or distances between narrow limits.
2. To determine the errors in geometrical form such as ovality, roundness and taper.
3. For taking accurate measurement of deformation such as intension and compression.
4. To determine positional errors of surfaces such as parallelism, squareness and alignment.
5. To check the alignment of lathe centers by using suitable accurate bar between the centers.
6. To check trueness of milling machine arbours and to check the parallelism of shaper arm with table surface or vice.

**b) Johansson Mikrokator :**

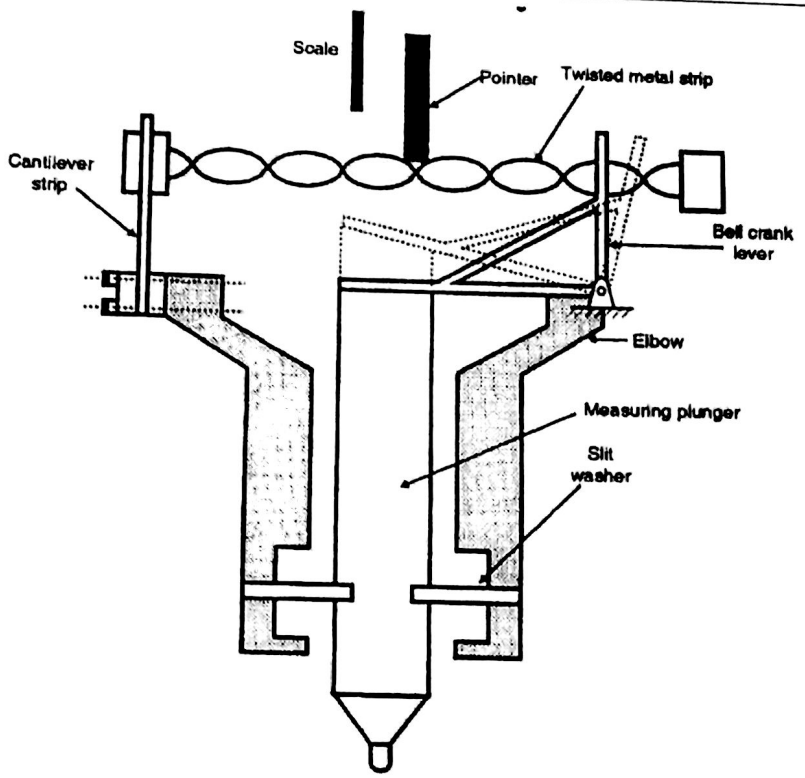
This comparator was developed by C.F. Johansson.

**Principle:**

It works on the principle of a Button spring, spinning on a loop of string like in the case of Children's toys.

**Construction:**

The method of mechanical magnification is shown in Figure. It employs a twisted metal strip. Any pull on the strip causes the centre of the strip to rotate. A very light pointer made of glass tube is attached to the centre of the twisted metal strip. The measuring plunger is on the slit washer and transmits its motion through the bell crank lever to the twisted metal strip. The other end of the twisted metal strip is fastened to the cantilever strip. The overhanging length of the cantilever strip can be varied to adjust the magnification of the instrument. The longer the length of the cantilever, the more it will deflect under the pull of the twisted metal strip and less rotation of the pointer is obtained.




When the plunger moves by a small distance in upward direction the bell crank lever turns to the right hand side. This exerts a force on the twisted strip and it causes a change in its length by making it further twist or untwist. Hence the pointer at the centre rotates by some amount. Magnification up to 5000X can be obtained by this comparator

**Advantages of Mechanical Comparator:**

1. They do not require any external source of energy.
2. These are cheaper and portable.
3. These are of robust construction and compact design.
4. The simple linear scales are easy to read.
5. These are unaffected by variations due to external source of energy such air, electricity etc.

**Disadvantages:**

1. Range is limited as the pointer moves over a fixed scale.
2. Pointer scale system used can cause parallax error.
3. There are number of moving parts which create problems due to friction, and ultimately the accuracy is less.
4. The instrument may become sensitive to vibration due to high inertia.

**e) Mechanical - Optical Comparator:**

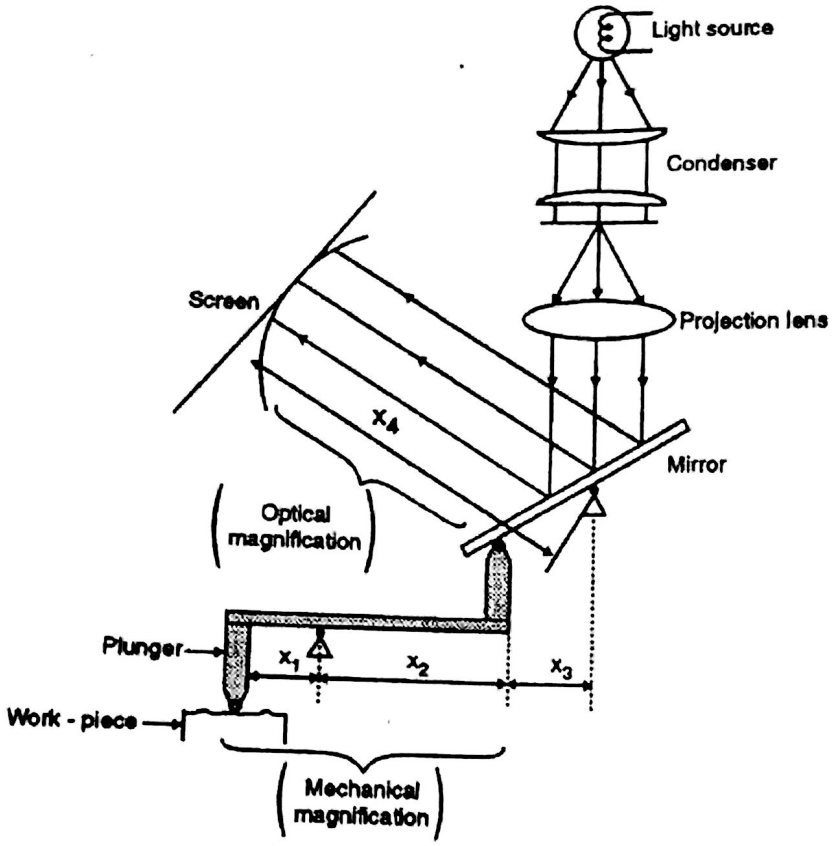
**Principle:**

In mechanical optical comparator, small variation in the plunger movement is magnified: first by mechanical system and then by optical system.

**Construction:**

The movement of the plunger is magnified by the mechanical system using a pivoted lever. From the Figure the mechanical magnification = x2 / x1. High optical magnification is

possible with a small movement of the mirror. The important factor is that the mirror used is of front reflection type only.




The back reflection type mirror will give two reflected images as shown in Figure, hence the exact reflected image cannot be identified.

**Advantages:**

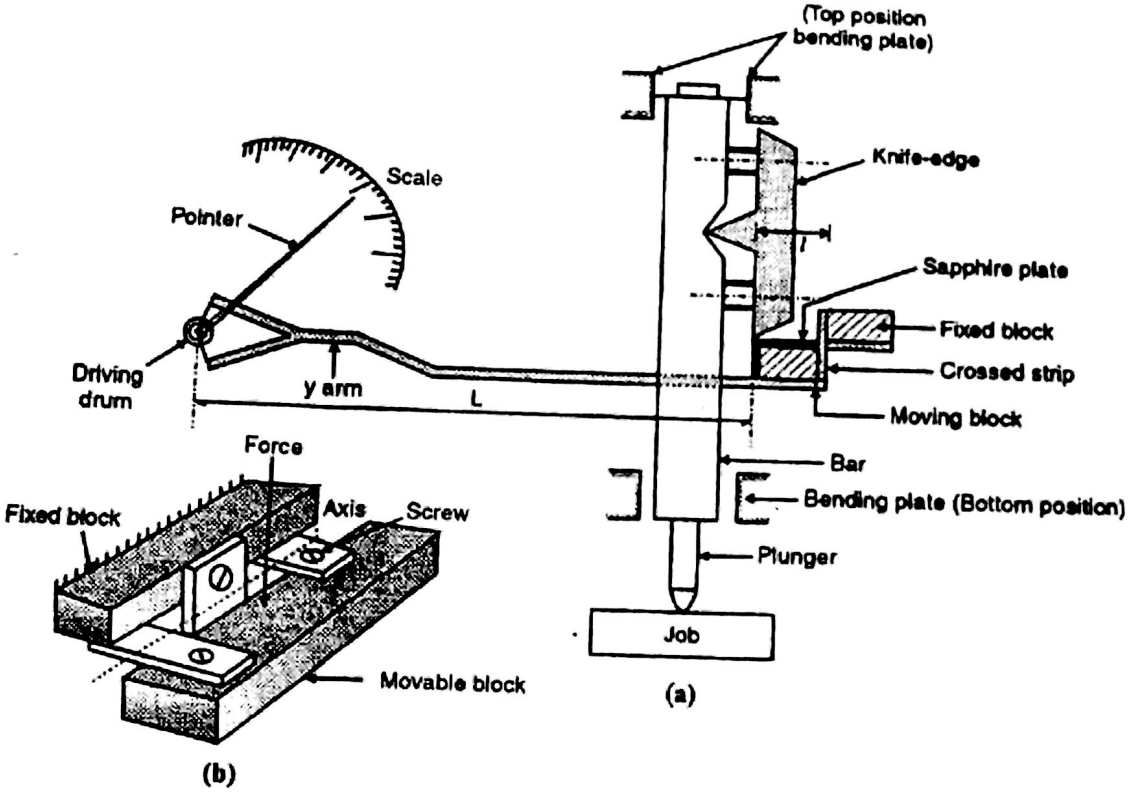
1. These Comparators are almost weightless and have less number of moving parts, due to this there is less wear and hence lessfriction.70
2. Higher range even at high magnification is possible as the scale moves past the index.
3. The scale can be made to move past a datum line and without having any parallax errors.
4. They are used to magnify parts of very small size and of complex configuration such as intricate grooves, radii or steps.

**Disadvantages:**

1. The accuracy of measurement is limited to 0.001 mm
2. They have their own built in illuminating device which tends to heat the instrument.
3. Electrical supply is required.
4. Eyepiece type instrument may cause strain on the operator.
5. Projection type instruments occupy large space and they are expensive.
6. When the scale is projected on a screen, then it is essential to take the instrument to a dark room in order to take the readings easily.

**d) Sigma Comparator:**

The plunger is attached to a bar which is supported between the bending plates at the top and bottom portion as shown in Figure (a)




The bar is restricted to move in the vertical direction. A knife edge is fixed to the bar. The knife edge is attached to the sapphire plate which is attached to the moving block. The knife edge extorts a force on the moving block through sapphire plate. Moving block is attached to the fixed block with the help of crossed strips as shown in Figure (b). When the force is applied on the moving block, it will give an angular deflection. A Y-arm which is attached to the moving block transmits the rotary motion to the driving drum of radius r. This deflects the pointer and then the reading is noted.

If l = Distance from hinge pivot to the knife edge
L = Length of y-arm
R = Driving drum radius
D Length of the pointer
Then the total magnification = (L/l) *(D/R)

**Electrical Comparators:**

Electrical comparators give a wide range of advantages. As we know, components like levers, gears, racks and pinions, activate mechanical devices. The accuracy and life of the instruments are affected as they are subjected to wear and friction

## Pneumatic Comparators (Solex Gauge):

**Principle:**

It works on the principle of pressure difference generated by the air flow. Air is supplied at constant pressure through the orifice and the air escapes in the form of jets through a restricted space which exerts a back pressure. The variation in the back pressure is then used to find the dimensions of a component.

**Working:**

As shown in Figure (a) the air is compressed in the compressor at high pressure which is equal to Water head H. The excess air escapes in the form of bubbles. Then the metric amount of air is passed through the orifice at the constant pressure. Due to restricted area, at A1 position, the back pressure is generated by the head of water displaced in the manometer tube. To determine the roundness of the job, the job is rotated along the jet axis, if no variation in the pressure reading is obtained then we can say that the job is perfectly circular at position A1.

Then the same procedure is repeated at various positions A2, A3, A4, position and variation in the pressure reading is found out. Also the diameter is measured at position A1 corresponding to the portion against two jets and diameter is also measured at various position along the length of the bore

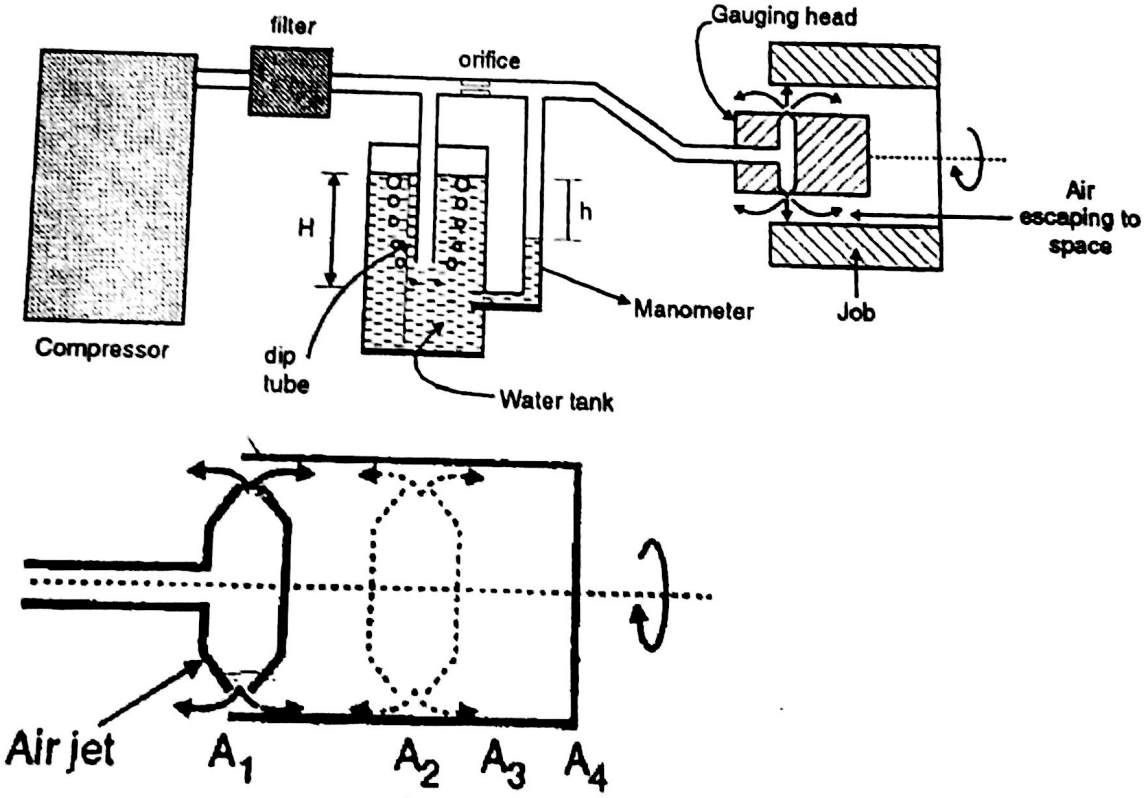



Figure (b)

Any variation in the dimension changes the value of h, e.g. Change in dimension of 0.002 mm changes the value of h from 3 to 20 mm. Moderate and constant supply pressure is required to have the high sensitivity of the instrument.

**Advantages:**

1. It is cheaper, simple to operate and the cost is low.
2. It is free from mechanical hysteresis and wear.
3. The magnification can be obtained as high as 10,000 X.
4. The gauging member is not in direct contact with the work.
5. Indicating and measuring is done at two different places.
6. Tapers and ovality can be easily detected.
7. The method is self cleaning due to continuous flow of air through the jets and this makes the method ideal to be used on shop floor for online controls.

**Disadvantages:**

1. They are very sensitive to temperature and humidity changes.
2. The accuracy may be influenced by the surface roughness of the component being checked.
3. Different gauging heads are needed for different jobs.
4. Auxiliary equipments such as air filters, pressure gauges and regulators are needed.
5. Non-uniformity of scale is a peculiar aspect of air gauging as the variation of back pressure is linear, over only a small range of the orifice size variation.

**Introduction to Angular Measurements:**

For measuring the angle, no absolute standard is required. The measurement is done in degrees, minutes and seconds. The measurement of angular and circular divisions is an important part of inspection. It is concerned with the measurement of individual angles, angular changes and deflections on components, gauges and tools. For precision measurement of angles more skill is required. Like linear measurement, angular measurements have their own importance. The basic difference between the linear and angular measurement is that no absolute standard is required for angular measurement. There are several methods of measuring angles and tapers. The various instruments used are angle gauges, clinometers, bevel protractor, sine bar, sine centers, taper plug and ring gauges

**Sine Bars:**

It is used for measurement of an angle of a given job or for setting an angle. They are hardened and precision ground tools for accurate angle setting. It can be used in conjunction with slip gauge set and dial gauge for measurement of angles and tapers from horizontal surface. As shown in Figure, two accurately lapped rollers are located at the extreme position. The center to center distance between the rollers or plugs is available for fixed distance i.e. l = 100, 200, 250, 300 mm. The diameter of the plugs or roller must be of the same size and the center distance between them is accurate. The important condition for the sine bar is that the surface of sine bar must be parallel to the center lines of the plug