



# ***Mechanical Measurements and Metrology***

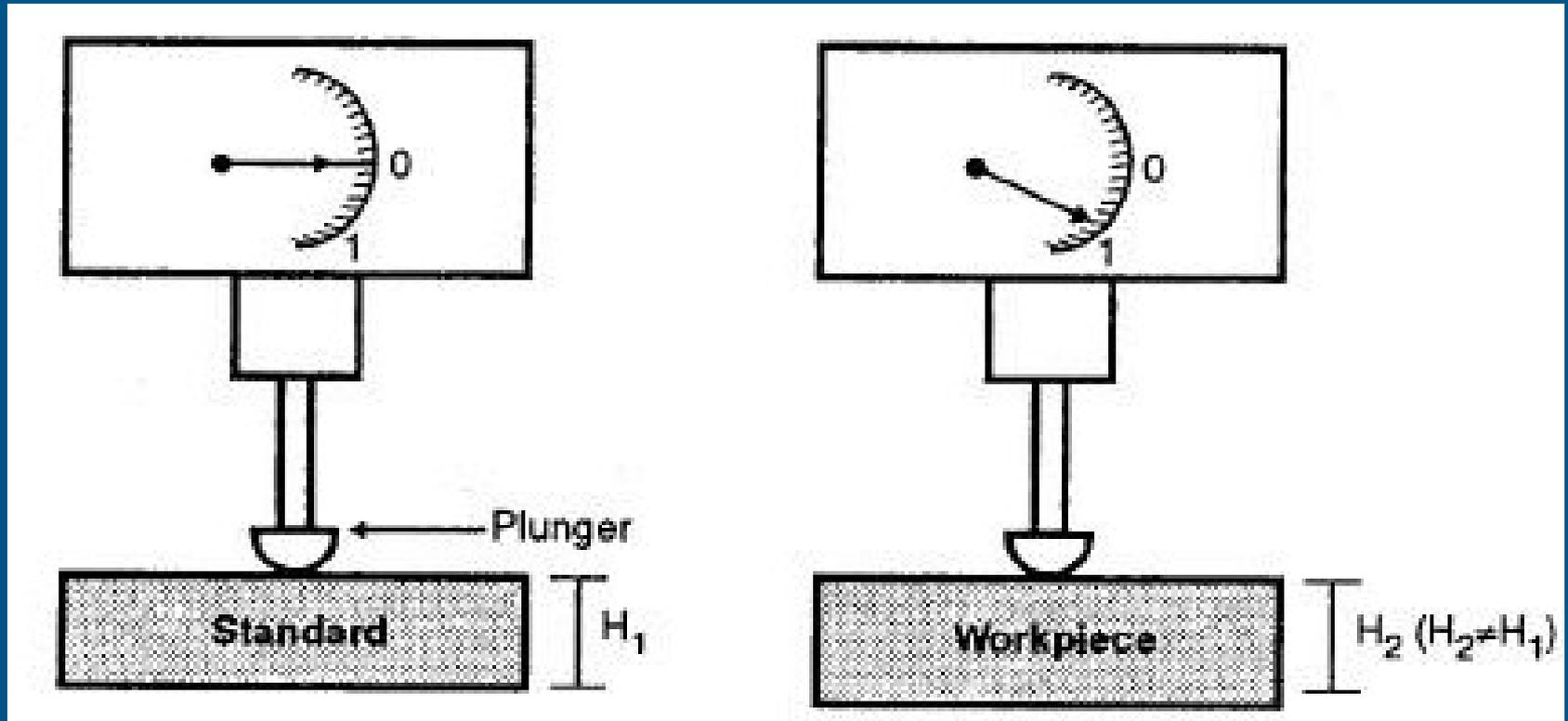
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# Comparators



# Introduction

The general principle of comparator is to indicate the differences in size between the standard and the work being measured by means of some pointer on a scale with sufficient magnification

It thus does not measure the actual dimension but indicates how much it differs from the basic dimension

# In short, Comparator is 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.

# BRIEF

- 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.

# NEED FOR A COMPARATOR

- (i) In mass production, where components are to be checked at a very fast rate.
- (ii) As laboratory standards from which working or inspection gauges are set and correlated.
- (iii) For inspecting newly purchased gauges.
- (iv) Attached with some machines, comparators can be used as working gauges to prevent work spoilage and to maintain required tolerances at all stages of manufacturing.
- (v) In selective assembly of parts, where parts are graded in three or more groups depending upon their tolerances.

# Characteristics of Good Comparators

1. Compact.
2. Easy to handle.
3. Quick response or quick result.
4. Reliable, while in use.
5. No effects of environment
6. Less weight .
7. Cost
8. Availability
9. Sensitivity
10. It should be linear in scale so that it is easy to read and get uniform response

# TYPES

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.
7. Fluid displacement comparators
8. Projection comparators

# Mechanical Type (The usual 250 to 1000 X)

- 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.

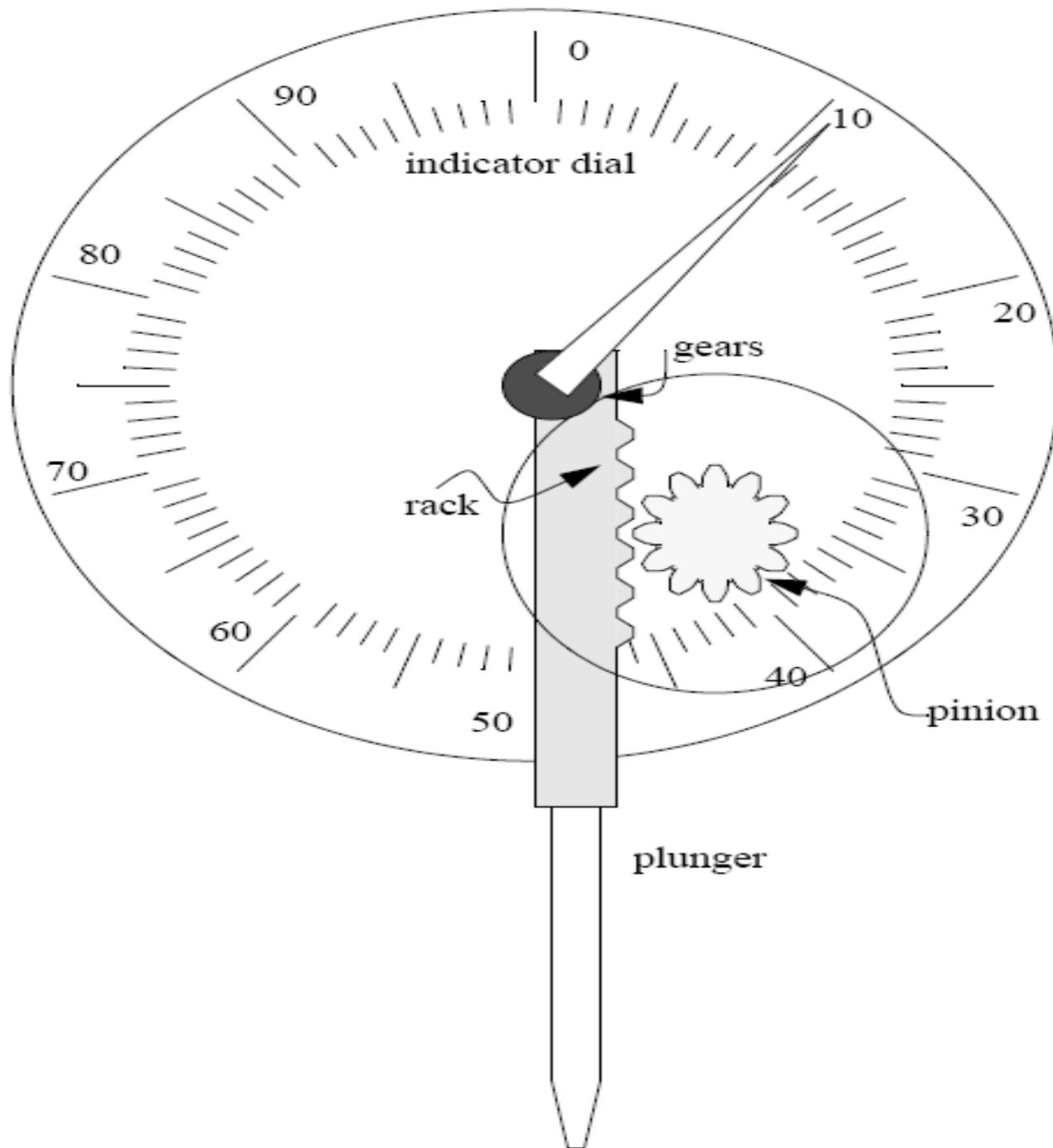
# The various types of mechanical comparators are

1. Dial indicator,
2. Rack and pinion,
3. Sigma comparator,
4. Johansson Mikrokator.

# 1. Dial indicator / Dial Gauge



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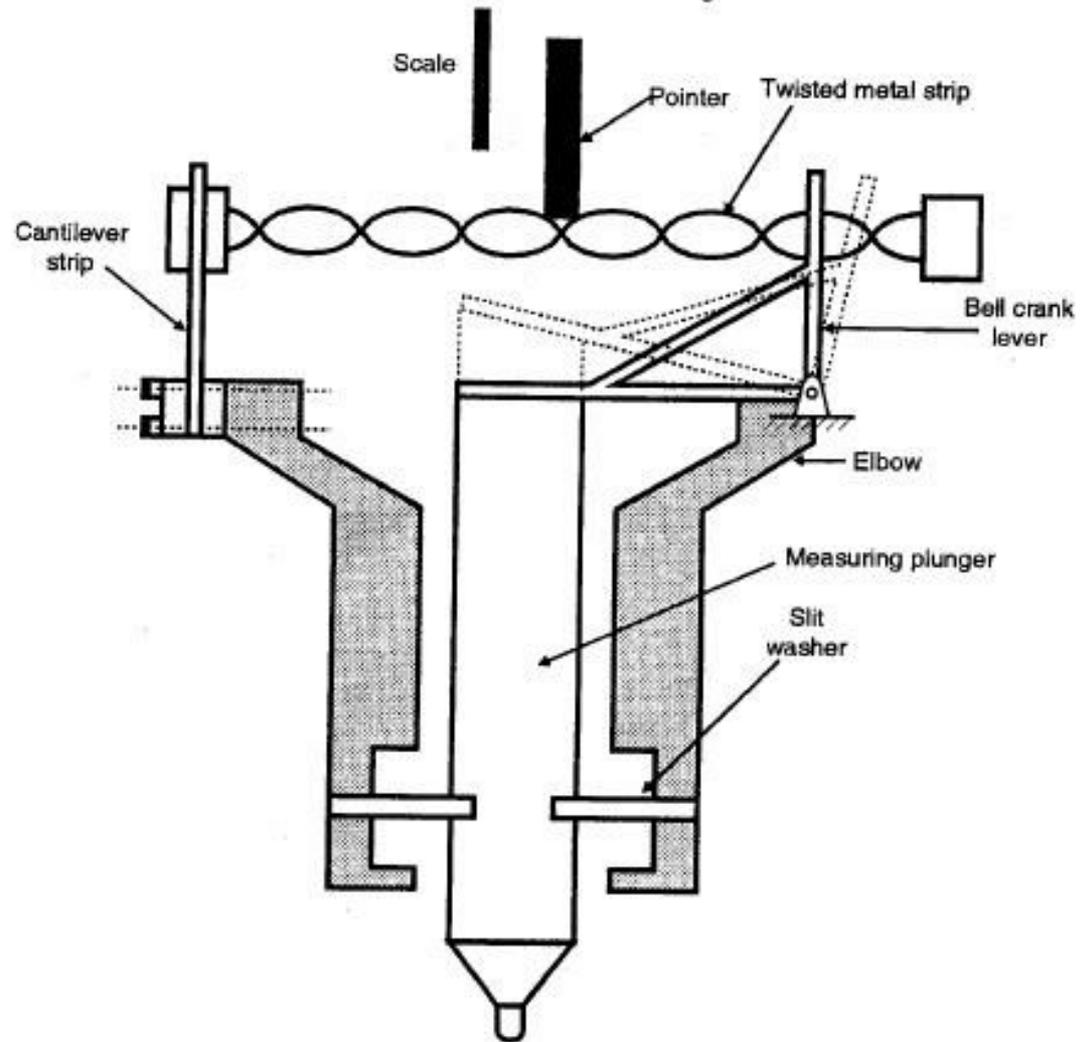
# Working

- ❑ 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

# Application

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.
7. Checking of components with a tolerance of  $\pm 0.005$  mm

# Johansson Mikrokator



# Working Principle

- A very thin metal strip at the centre carries a light pointer made up of glass .
- One end of the strip is connected to the adjustable cantilever strip and the other end is to the spring elbow, in turn connected to the plunger.
- The slight movements of the plunger will make the bell crank lever to rotate.
- This rotation will create tension in the strip and causes the strip to rotate thereby the strip start to untwist resulting in the movement of the point
- Magnification up to 5000X can be obtained by

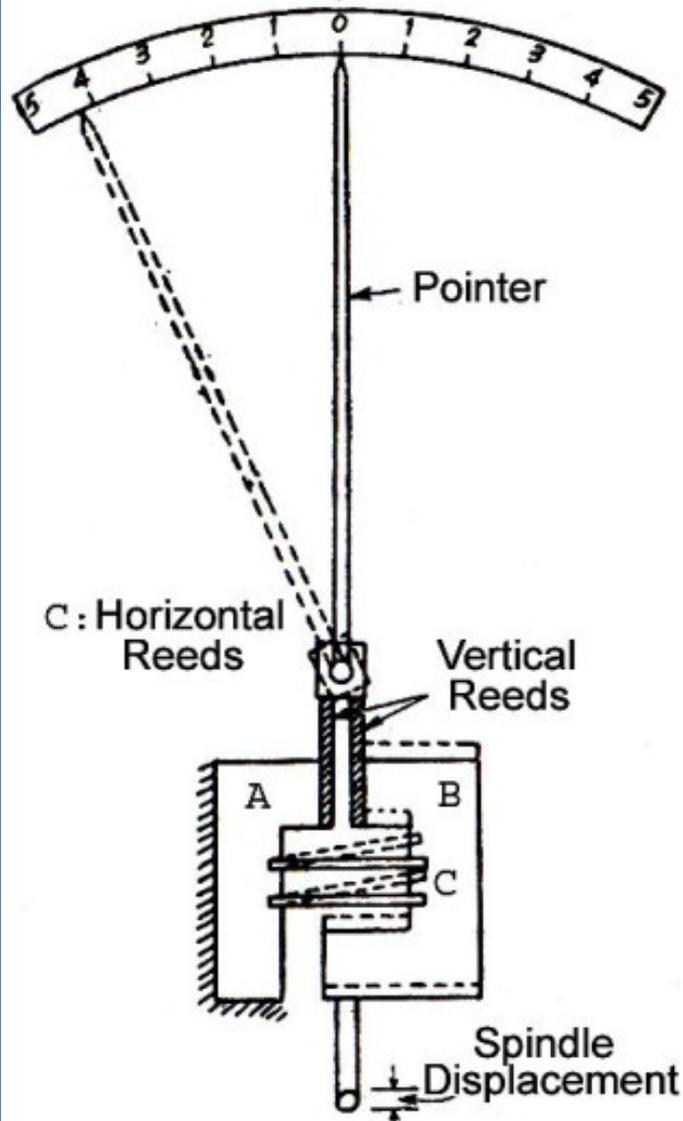
# PROS

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.

## Cons (LIMITATIONS)

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.

# REED TYPE

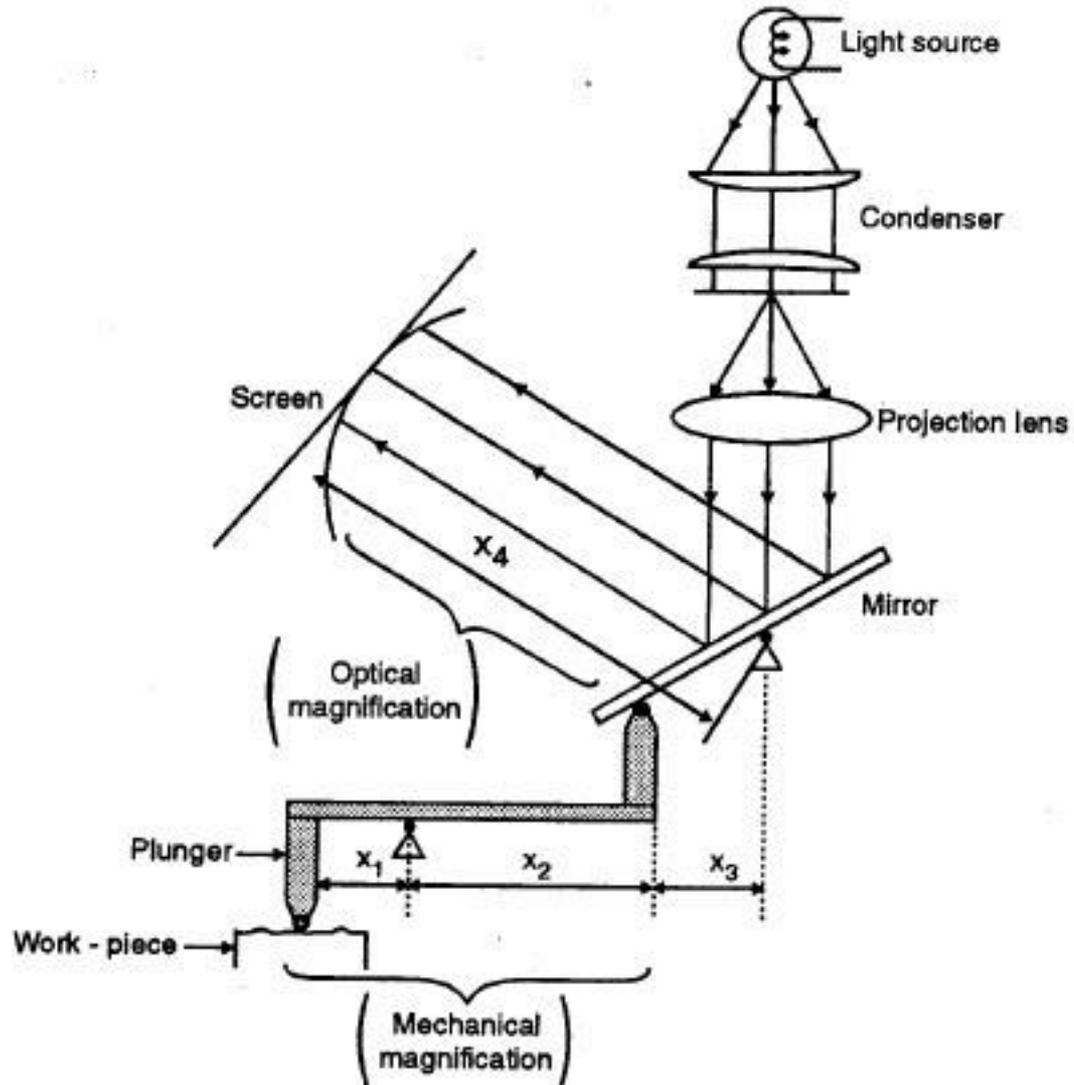


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# Working Principle

- ❖ The amount of target swing is proportional to the distance the floating block has moved but of course very much magnified.
- ❖ The scale may be calibrated by means of gauge block (slip gauges) to indicate any deviation from an initial setting.
- ❖ Sensitivities of the order of 0.25 micron per scale division.
- ❖ The mechanical amplification is usually less than 100, but it is multiplied by the optical lens system.
- ❖ It is available in amplifications ranging from x 500 to x 1000.

# Mechanical - Optical



# Working Principle

- In mechanical optical comparator, small variation in the plunger movement is magnified: first by mechanical system and then by optical system.
- In mechanical optical comparators small displacements of the measuring plunger are amplified first by a mechanical system consisting of pivoted levers.
- The amplified mechanical movement is further amplified by a simple optical system involving the projection of an image.

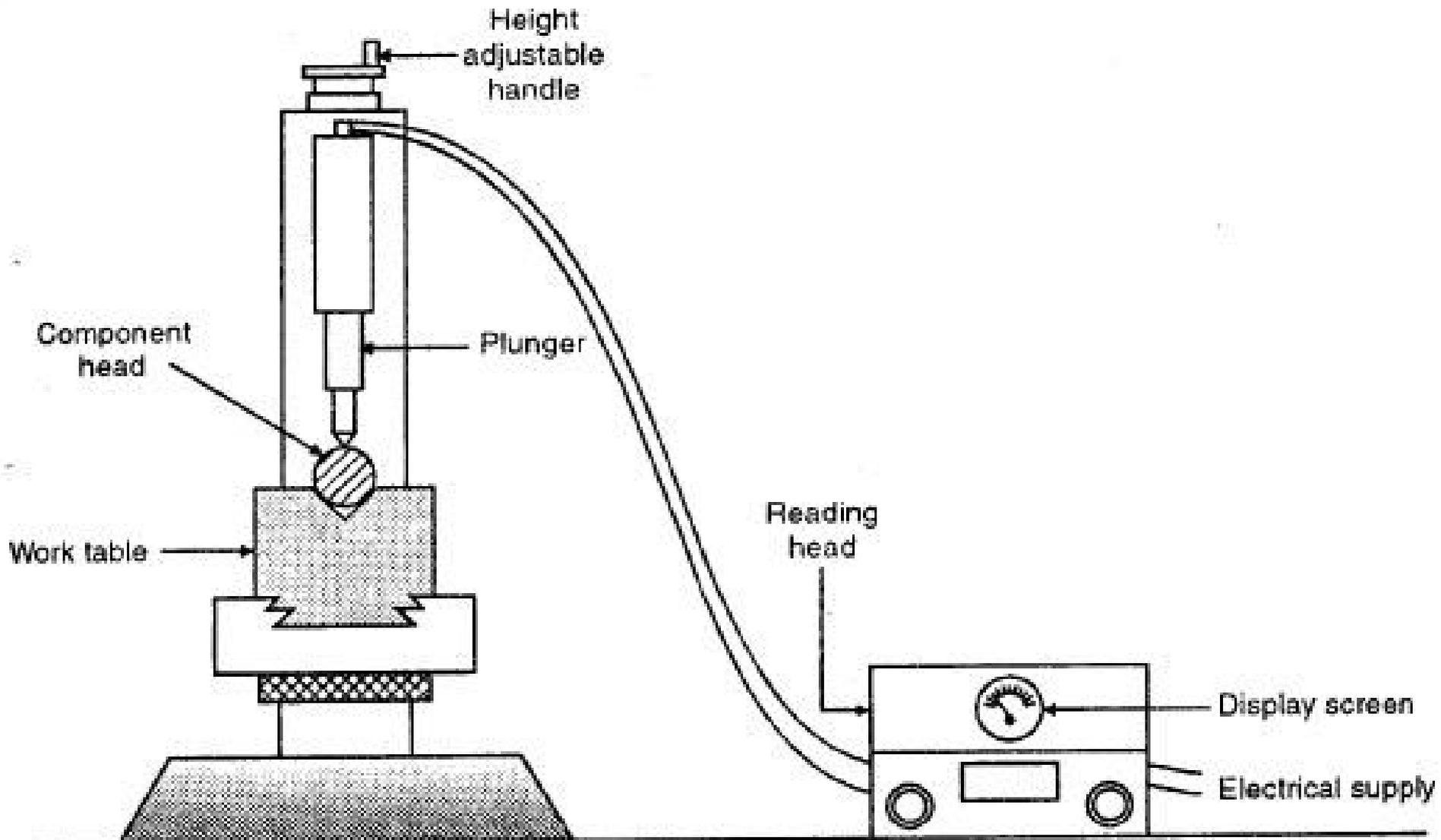
# PROS

1. These Comparators are almost weightless and have less number of moving parts, due to this there is less wear and hence less friction.
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.

## Cons

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.

# ELECTRICAL TYPE



# Working Principle

- In electrical comparators, the movement of the measuring contact is converted into an electrical signal.
- The electrical signal is recorded by an instrument which can be calibrated in terms of plunger movement.
- For this an AC wheatstone bridge circuit incorporating a galvanometer is used. It can rather be said that all the electronic comparators work on the principle of wheatstone bridge.
- Electrical comparators have no moving parts. Thus a high degree of reliability is expected from these instruments.

# Pros:

1. Measuring units can be remote from indicating units.
2. Variable sensitivity which can be adjusted as per requirement.
3. No moving parts, hence it can retain accuracy over long periods.
4. Higher magnification is possible as compared to mechanical comparator.
5. Compact sizes of probes are available.

# Cons

- The accuracy of working of these comparators is likely to be affected due to temperature and humidity.
- It is not a self-contained unit; it needs a stabilized power supply for its operation.
- Heating of coils can cause zero drifts and it may alter calibration.
- It is more expensive than a mechanical comparator.

# Pneumatic Comparators

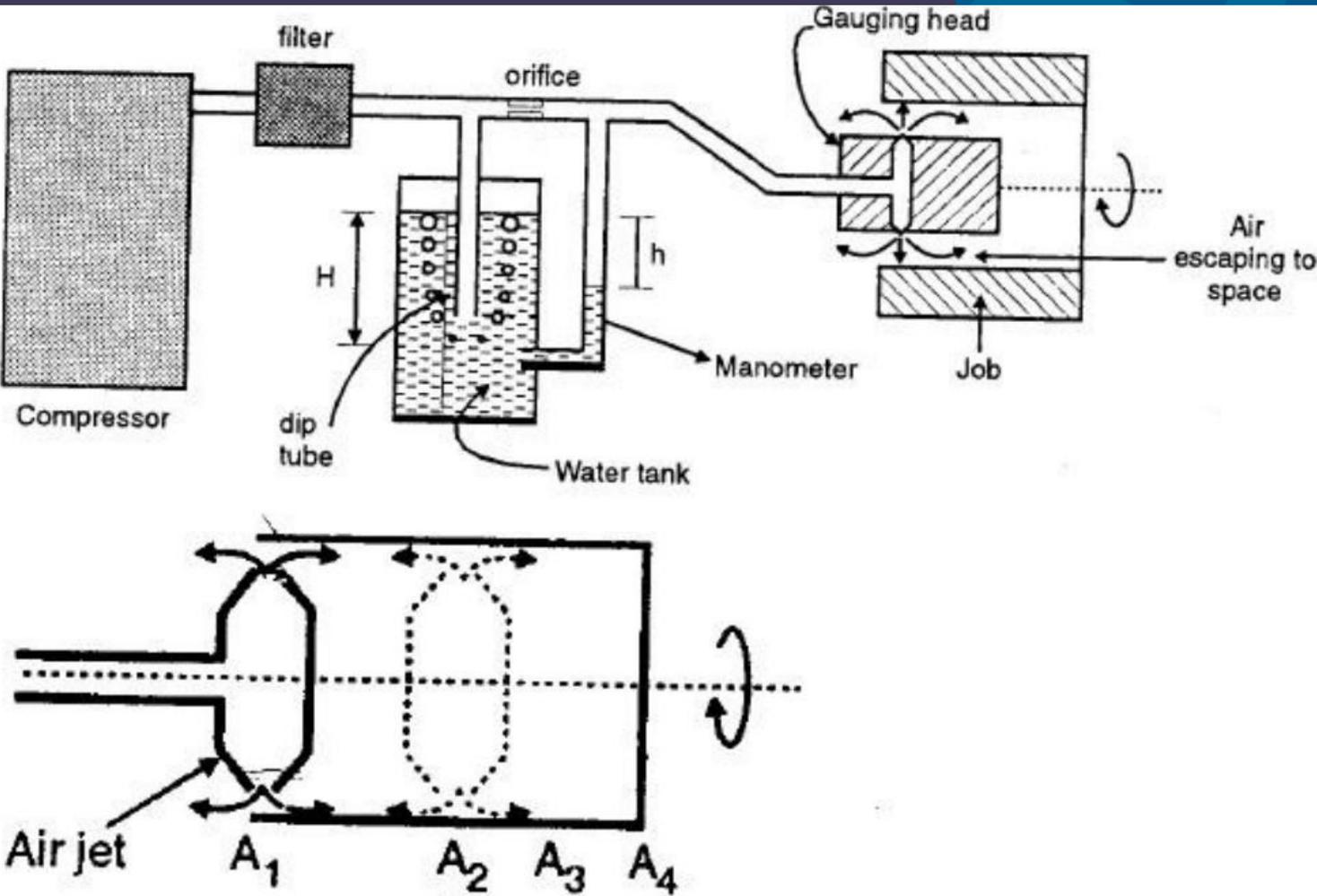


Figure (b)

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# Working 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.

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

# PROS

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.

# CONS

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