COMPARATORS

- An instrument or machine for comparing anything to be measured with a standard measure.

- It cannot measure the dimensions but indicates how much it differs from the basic size

Principle

The general principle of comparator is to indicate the difference in size b/w the standard and the work being measured by means of some pointer on the scale with sufficient magnification.

BASIC FEATURES

- **A sensing device**: Which senses the input signal
- **A magnifying or an amplifying system**: to increase the input to the suitable magnitude. Mechanical, optical, pneumatic, hydraulic, electronic methods are used for this purpose.
- **A display system(usually a scale or a pointer):**which utilizes the amplified signal to provide a suitable output.

Need for comparators

- A comparator is used in mass production to inspect the components to close tolerances with high degree of precision and speed.
- Many dimensions can be checked in a very short time
- Little or no skill for operator is required.

BASIC OPERATIONS

- The comparators are first adjusted to zero on its dial with a gauge block in position.
- The work piece to be checked is then placed in position.
- The comparator gives the difference in dimensions in relation to the gauge block.

USES OF COMPARATOR

- **Laboratory standards**: to set the working or inspection gauges.
- **Working gauges**: to prevent the work spoilage and to maintain required tolerance.
- **Final inspection gauges.**
- **Receiving inspection gauges.**
- **For checking newly purchased gauges.**

CLASSIFICATION

- Mechanical comparators.
- Optical comparators.
- Electrical and Electronic comparators.
- Pneumatic comparators
- Fluid displacement comparators
- Mechanical optical comparator
- Electro mechanical comparator
- Multi check comparator

MECHANICAL COMPARATOR

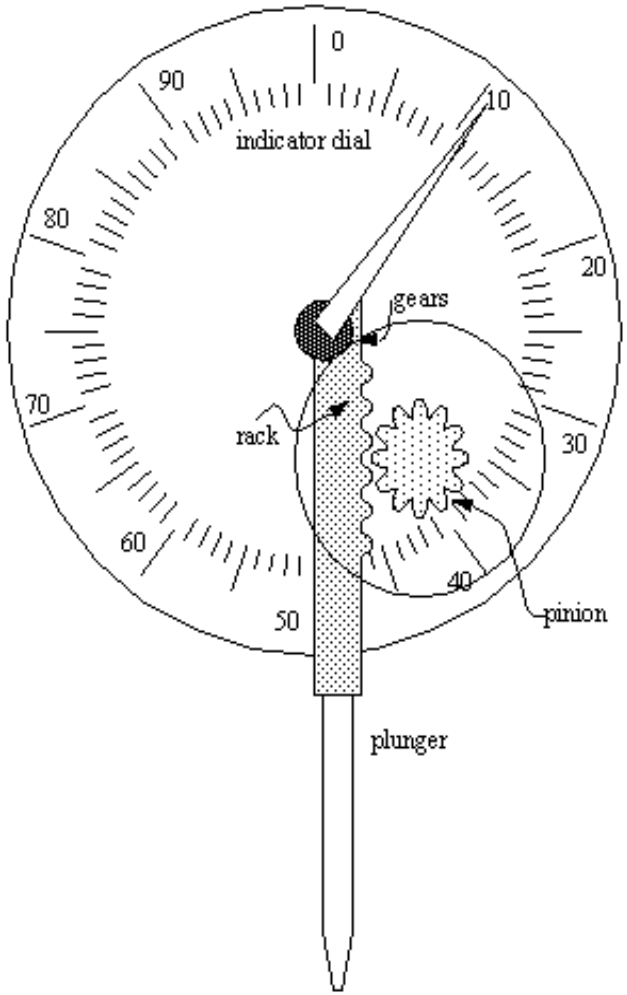
Working principle:

It employs mechanical means for magnification. The magnification of the small stylus movement is obtained by means of levers, gears trains, rack and pinion or a combination. Usual magnification obtained is about 250 to 1000 times.

TYPES OF MECHANICAL COMPARATORS

- **Dial Indicator (Dial Gauge)**
- Reed Type
- Johansson Mikrokator
- **Sigma Comparator**

DIAL INDICATOR /DIAL GAUGE



Mechanism

- The simplest type of mechanical comparator
- It consists of a dial connected to plunger projecting at its bottom.
- The plunger moves upward when a very slight upward pressure as applied.
- The mechanism has a system connected to the toothed rack. A compound gear is provided to connect toothed rack to pointer.
- When pressure is released the pointer moves. The indicator is adjusted to zero by rotating dial rim.
- The part to be checked is placed below the plunger

•The linear movement of the plunger is magnified by means of mechanical means to a suitable rotation of the pointer.

•The minimum reading of dial is 0.01mm.

• A revolution counter in form of a small dial is provided to indicate the total travel by stem.

•This type is generally used for inspection of small precision machined parts.

•Checking of components with a tolerance of ±0.005mm.

SIGMA COMPARATOR

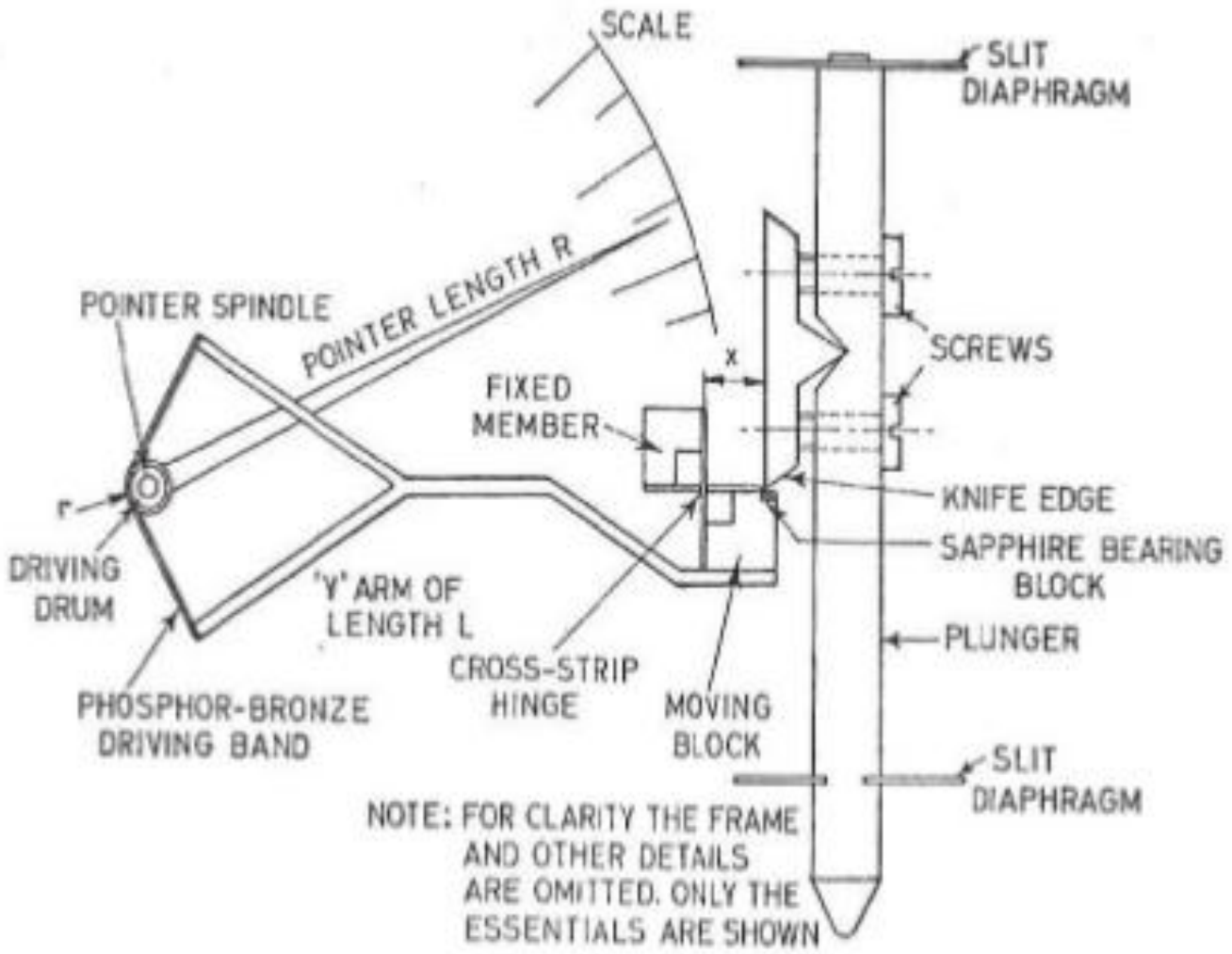


Fig. 3.14. Diagram of movement of Sigma mechanical comparator.

- It consist of a plunger mounted on two flat springs.
- The plunger holds a knife edge which bears upon the face of the moving block of the cross strip hinge.
- The displacement in vertical direction of the plunger makes moving block of the cross strip lever to pivot. This cause rotation of arm ‘y’, the metallic band attached to the arm make the driving drum and the pointer to rotate.
- The ratio of effective length (Y) of the arm and distance (x) of the knife edge from the pivot gives the first stage magnification.

- Magnification :

If Y = length of the forked arm

X = distance from the knife edge to the hinge

Then the 1st stage magnification = Y/X

If 'R' = the pointer length

r = radius of drum

Then 2nd stage of magnification = R/r

$$\text{Total magnification } M = Y/X \times R/r$$

The magnification preset by the manufacture may be varied by adjusting the knife edge attachment screws.

Another way to produce instrument of different magnification is to use drum of different radius 'r' with a suitable strip.

Advantages

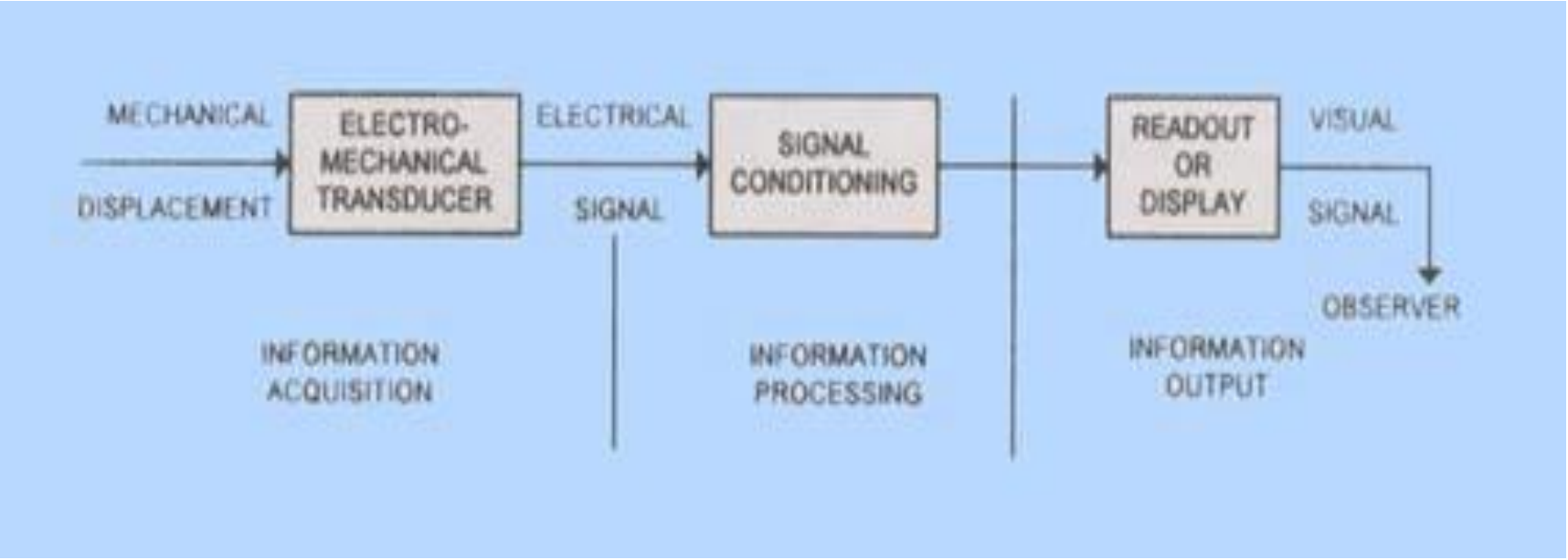
- Cheaper.
- Do not require any external supply.
- Linear scale for easy understanding.
- Robust, compact, easy to handle.
- Portable and suitable for ordinary workshop condition.

Disadvantages

- More moving parts so friction is more.
- Slackness in moving reduces their accuracy considerably.
- The mechanism has more inertia and this may cause the instrument to be sensitive to variation.
- Range limited as pointer moves over a fixed scale.

ELECTRICAL AND ELECTRONIC COMPARATORS

Electrical comparators are also known as electro- mechanical measuring systems as these employ an electro- mechanical device which converts a mechanical displacement into electrical signal



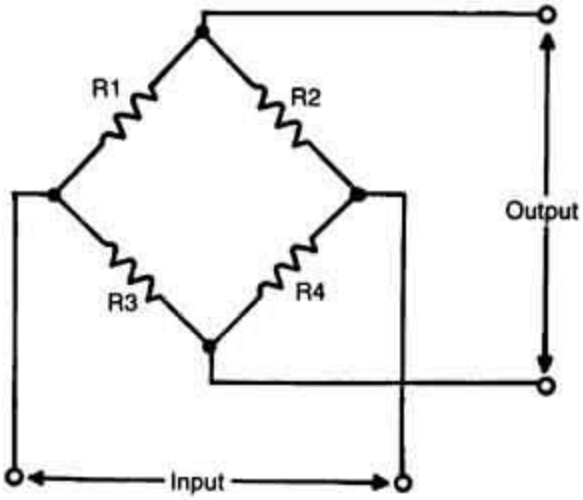
These comparators depend for their operation on Wheatstone bridge circuit.

Wheatstone Bridge:

A simple circuit for measuring an unknown resistance by connecting it so as to form a quadrilateral with three known resistances and applying a voltage between a pair of opposite corners.

For the bridge to balance, the ratio of the resistances in each pair of arms must be equal i.e., $R_1/R_2 = R_3/R_4$.

This circuit is applicable only to direct current, which can be obtained from a battery, but if an alternating current is applied to such a bridge, the inductance and capacitance of the arms must be taken into account in addition to their resistances.



TYPES OF ELECTRICAL AND ELECTRONIC COMPARATORS

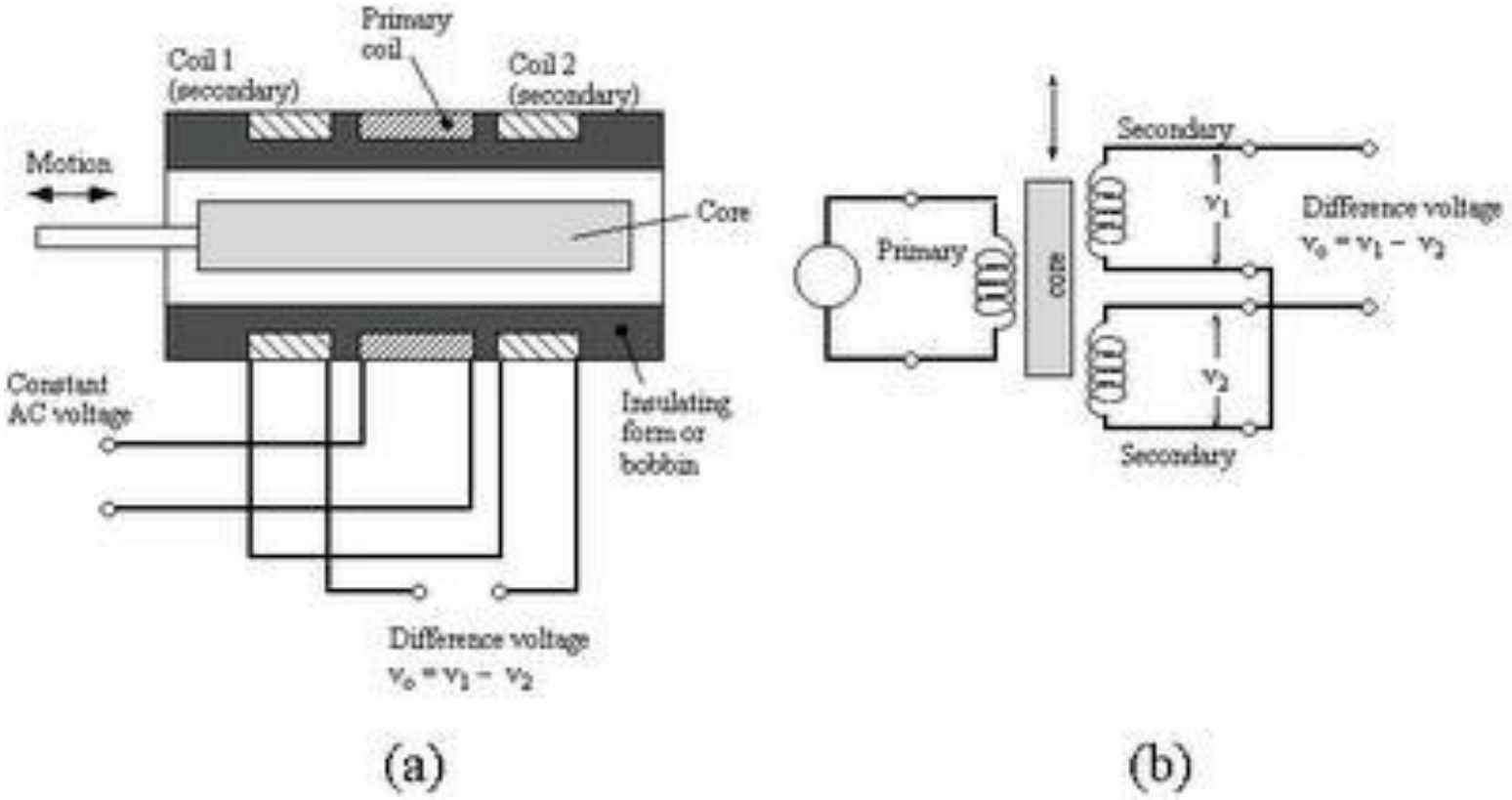
- Electrolimit gauge
- **LVDT (Linear Variable Differential Transformer)**

Linear Variable Differential Transformer

LVDT is the most popular electro mechanical device used to convert mechanical displacement into electrical signal.

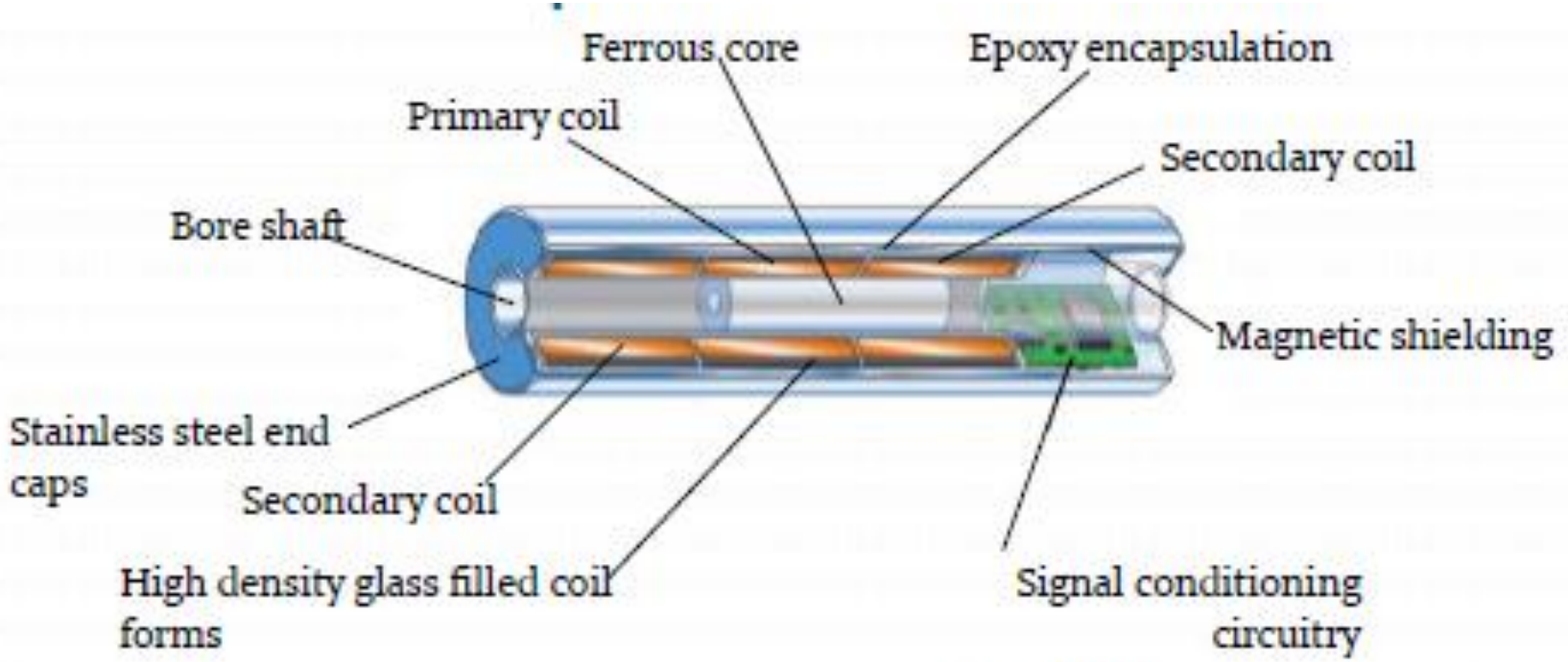
Principle of LVDT

- LVDT works under the principle of mutual induction, and the displacement which is a non-electrical energy is converted into an electrical energy.
- LVDT consists of a cylindrical former where it is surrounded by one primary winding in the centre of the former and the two secondary windings at the sides. The number of turns in both the secondary windings are equal, Iron core is placed in the centre of the cylindrical former which can move in to and fro motion



This is a LVDT. Linear movement of the core changes the Impedance. The electrical output changes in proportion to the core movement.

LVDT COMPONENTS

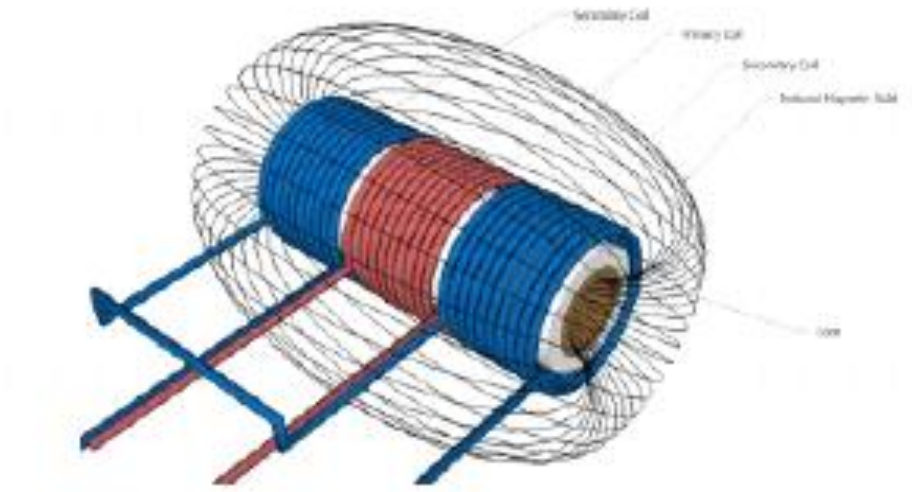


Cross section of a LVDT

Underlying Principle

Electromagnetic Induction:

- Primary Coil **(RED) is connected to power source**
- Secondary Coils **(BLUE) are connected in parallel but with opposing polarity**
- Primary coil's magnetic field **(BLACK) induces a current in the secondary coils**
- Ferro-Metallic core **(BROWN) manipulates primary's magnetic field**



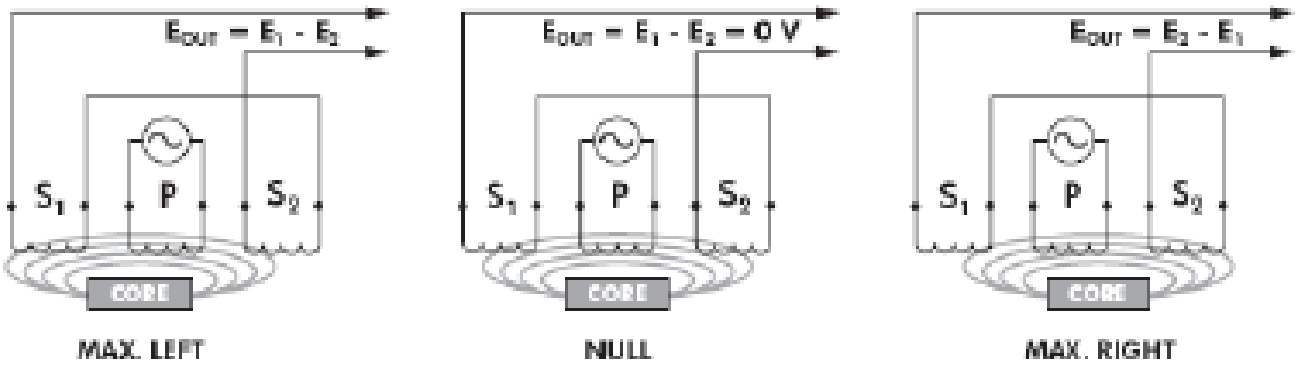
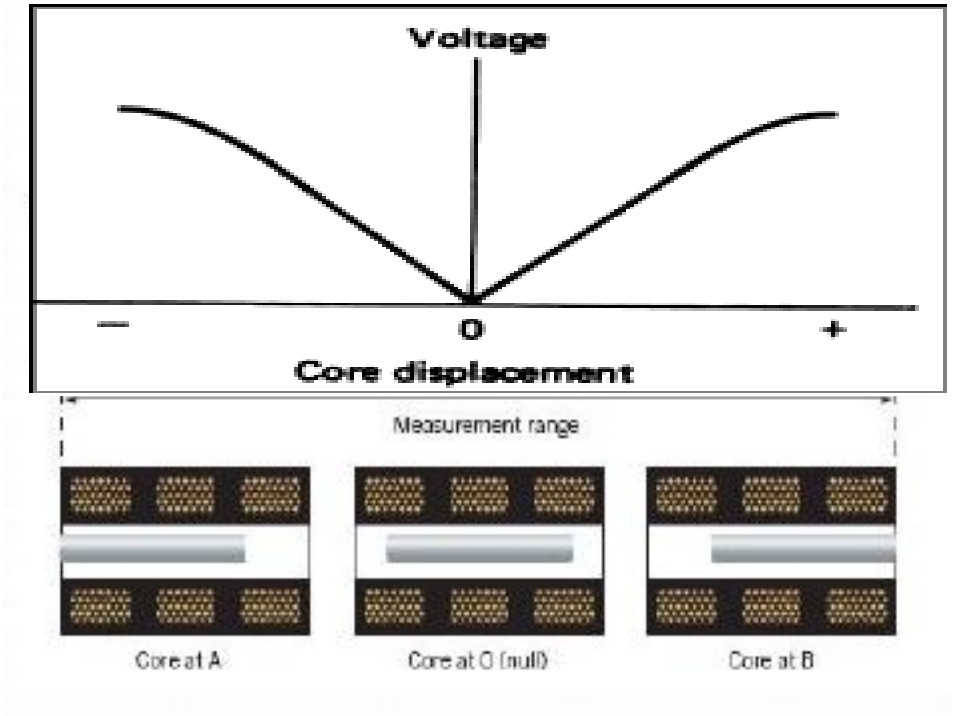

$E_{OUT} = E_1 - E_2$
S_1
P
S_2
CORE
MAX. LEFT
$E_{OUT} = E_1 - E_2 = 0$ V
S_1
P
S_2
CORE
NULL
$E_{OUT} = E_2 - E_1$
S_1
P
S_2
CORE
MAX. RIGHT

Figure 2


Voltage
—
0
+
Core displacement
Measurement range
Core at A
Core at 0 (null)
Core at B

Working of LVDT

- **Case 1:** During displacement, if the core remains in the null position itself without providing any movement then the voltage induced in both the secondary windings are equal which results in net output is equal to zero i.e., Esec1-Esec2=0

- **Case 2:** When an external force is applied and if the steel iron core tends to move in the left hand side direction then the emf voltage induced in the secondary coil 1 is greater compared to the secondary coil 2. Therefore the net output will be Esec1- Esec2

- **Case 3:** When an external force is applied and if the steel iron core moves in the right hand side direction then the emf induced in the secondary coil 2 is greater compared to the secondary coil 1. therefore the net output voltage will be Esec2- Esec1.

Advantages

- The mechanism carrying the pointer is very light and not sensitive to vibration.
- The measuring unit is compact and can have several magnifications.
- The measuring unit can be remote from the indicting instruments.
- These comparators have high magnifications wit less number of moving parts.

Disadvantages

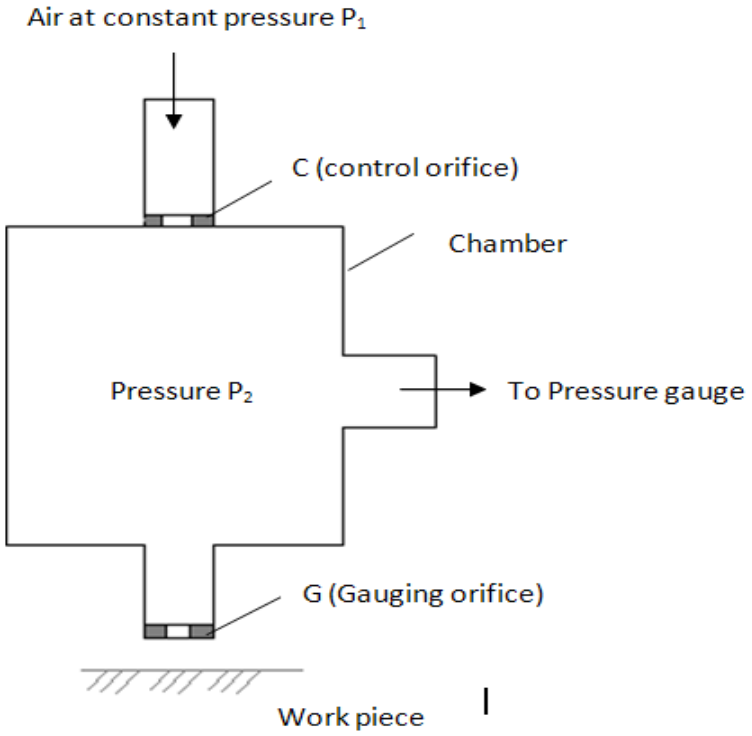
- It requires an external agency to operate i.e., the A.C. electrical supply. Thus the variations in voltage or frequency of electric supply may affect the accuracy.
- Heating of coils in the measuring unit may cause zero drift and alter the calibration.
- If only a fixed scale is used with a moving core then with high magnifications a very small range is obtained.
- This is usually more expensive than mechanical instrument.

Pneumatic Comparators

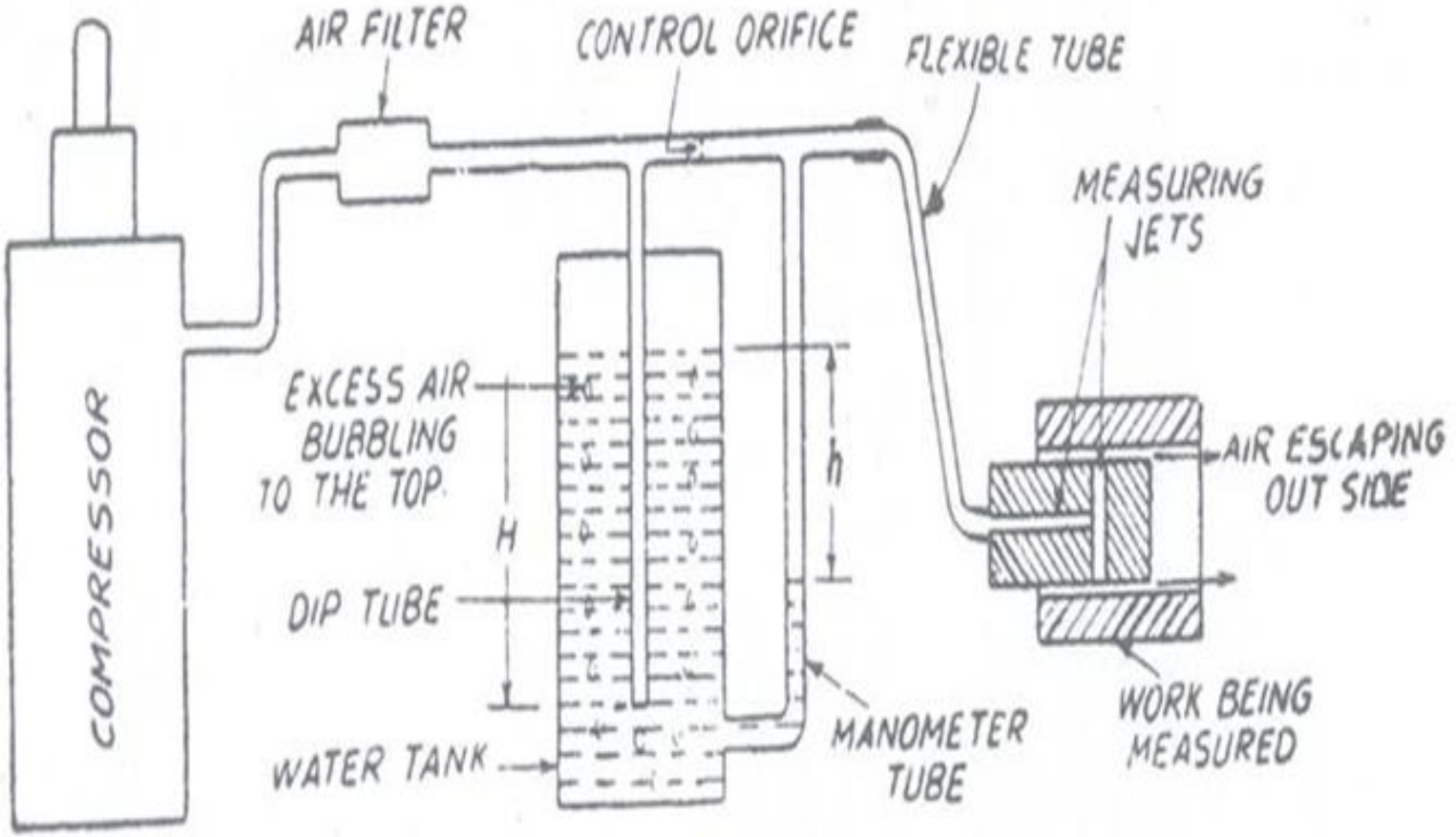
- Air is used as means of magnification.
- No physical contact is made either with the setting gauge or the part being measured.
- Very high amplifications are possible.
- It is independent of operator skill.
- High pressure air gauging can be done.
- Out of roundness, taperness, concentricity, regularity can be measured
- Not only it measures the actual size, but it can also be used to salvage oversized pieces for rework or to sort out for selective assembly.
- Pneumatic comparators works on the principle of an airjet.
- It is best suited for checking multiple dimensions and conditions on a part simultaneously in least possible time. It can be used for parts from 0.5 mm to 900 mm diameter having tolerance of 0.05 mm or less. It can be easily used for on line measurement of parts as they are being machined and take corrective actions

Principle of Pneumatic comparators

- Pneumatic comparators work on the principle that, an air-jet is in close proximity with a surface, the flow of air out of that jet is restricted.



SOLEX PNEUMATIC COMPARATOR



Construction.

- It was commercially introduced by solex Air gauges Ltd.
- It is generally designed for internal measurement, but with suitable measuring head it can be used for external gauging also.
- It uses water manometer for indication of back pressure.
- Consists of vertical metal cylinder filled with water up to a certain level & a dip tube immersed into it up to a depth corresponding to the air pressure required.
- A calibrated manometer tube is connected b/w the cylinder and control orifice.

Working.

- If the pressure of the air supplied is higher than the desired pressure, some air will be bubble out from the bottom of the dip tube and air moving to the control volume will be at the desired constant pressure.

- Constant pressure air then passes through the control orifice & escape of air, the level of water in the manometer tube will coincide with that in cylinder.

- But, if there is a restriction to the escape of air through the jets, a back pressure will be induced in the circuit and level of water in manometer tube will fall.

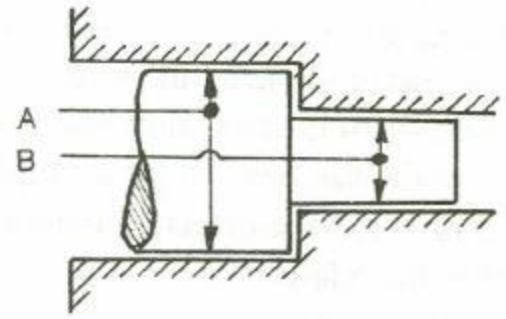
- The restriction to the escape of air depends upon the variations in the dimensions to be measured.

- Thus it is converted into corresponding pressure variations, which can be read from the calibrated scale provided with the manometer.

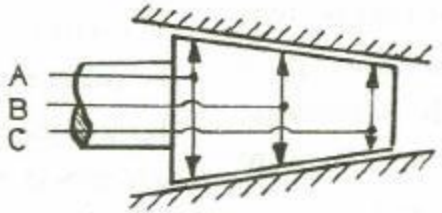
To find the concentricity (roundness of any job @ any section)

- Work piece may be revolved around measuring gauge.
- If no changes in the reading, then it is perfectly round hole.
- Similarly the diameter can be noted down at several places along the length of bore / tapering of hole is determines.
- Best suited for measuring roundness & taperness of cylinder bases and gun barrel bores.

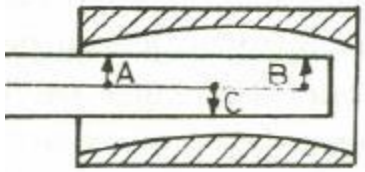
Applications of pneumatic comparators



(c) Multi - diameter



(d) Taper



(e) Bore straightness

Advantages

- Less number of moving parts & thus accuracy more due to the absence of friction & lower inertia
- Very high degree of magnification
- Measuring dia of holes where the dia is small compared with the length.
- Determining the ovality and taperness of the circular holes.
- Measuring pressure is very small & the jet of air helps in cleaning dust, if any, from the part to be measured.

Disadvantages

- The scale is generally not linear
- Required elaborate auxiliary equipment's such as accurate pressure regulator, compressor etc.
- Apparatus is not easily portable & is rather elaborate for many industrial applications.