MOHAMED SATHAK A J COLLEGE OF ENGINEERING

ME8501 METROLOGY AND MEASUREMENTS

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MSAJCE

UNIT I BASICS OF METROLOGY

Introduction to Metrology – Need – Elements – Work piece, Instruments – Persons – Environment –their effect on Precision and Accuracy – Errors – Errors in Measurements – Types – Control – Types of standards.

Introduction to Metrology

- **Metrology is a science of measurement.**
- **Metrology may be divided depending upon the quantity under consideration into: metrology of length, metrology of time etc.**
- **Depending upon the field of application it is divided into industrial metrology, medical metrology etc.**

Need of Inspection

1. To ensure that the part, material or a component conforms to the established standard.

2. To meet the interchangeability of manufacture.

3. To maintain customer relation by ensuring that no faulty product reaches the customers.

4. Provide the means of finding out shortcomings in manufacture.

5. It also helps to purchase good quality of raw materials, tools, equipment which governs the quality of the finished products.

6. It also helps to co-ordinate the functions of quality control, production, purchasing and other departments of the organization.

Standards

- 1. Primary standards
- 2. Secondary standards
- 3. Territory standards
- 4. Working standards.

1. Primary Standards

For precise definition of the unit, there shall be one, and only one material standard, which is to be preserved under most careful conditions. It is called as primary standard.International yard and International meter are the examples of primary standards. Primary standard is used only at rare intervals (say after 10 to 20 years) solely for comparison with secondary standards. It has no direct application to a measuring problem encountered in engineering.

2. Secondary Standards

Secondary standards are made as nearly as possible exactly similar to primary standards as regards design, material and length. They are compared with primary standards after long intervals and the records of deviation are noted. These standards are kept at number of places for safe custody. They are used for occasional comparison with tertiary standards whenever required.

3. Tertiary Standards

The primary and secondary standards are applicable only as ultimate control. Tertiary standards are the first standard to be used for reference purposes in laboratories and workshops. They are made as true copy of the secondary standards. They are used for comparison at intervals with working standards.

4. Working Standards

Working standards are used more frequently in laboratories and workshops. They are usually made of low grade of material as compared to primary, secondary and tertiary standards, for the sake of economy. They are derived from fundamental standards. Both line and end working standards are used. Line standards are made from H-cross-sectional form

Measuring system element

A measuring system is made of five basic elements. These are S.W.I.P.E. :

1. Standard
2. Work piece
3. Instrument
4. Person
5. Environment.

Methods of Measurement

The methods of measurement can be classified as:

1. Direct method
2. Indirect method
3. Absolute/Fundamental method
4. Comparative method
5. Transposition method
6. Coincidence method
7. Deflection method
8. Complementary method
9. Contact method
10. Contactless method etc.

Precision and Accuracy

Precision

The terms precision and accuracy are used in connection with the performance of the instrument. Precision is the repeatability of the measuring process.

Accuracy

Accuracy is the degree to which the measured value of the quality characteristic agrees with the true value.

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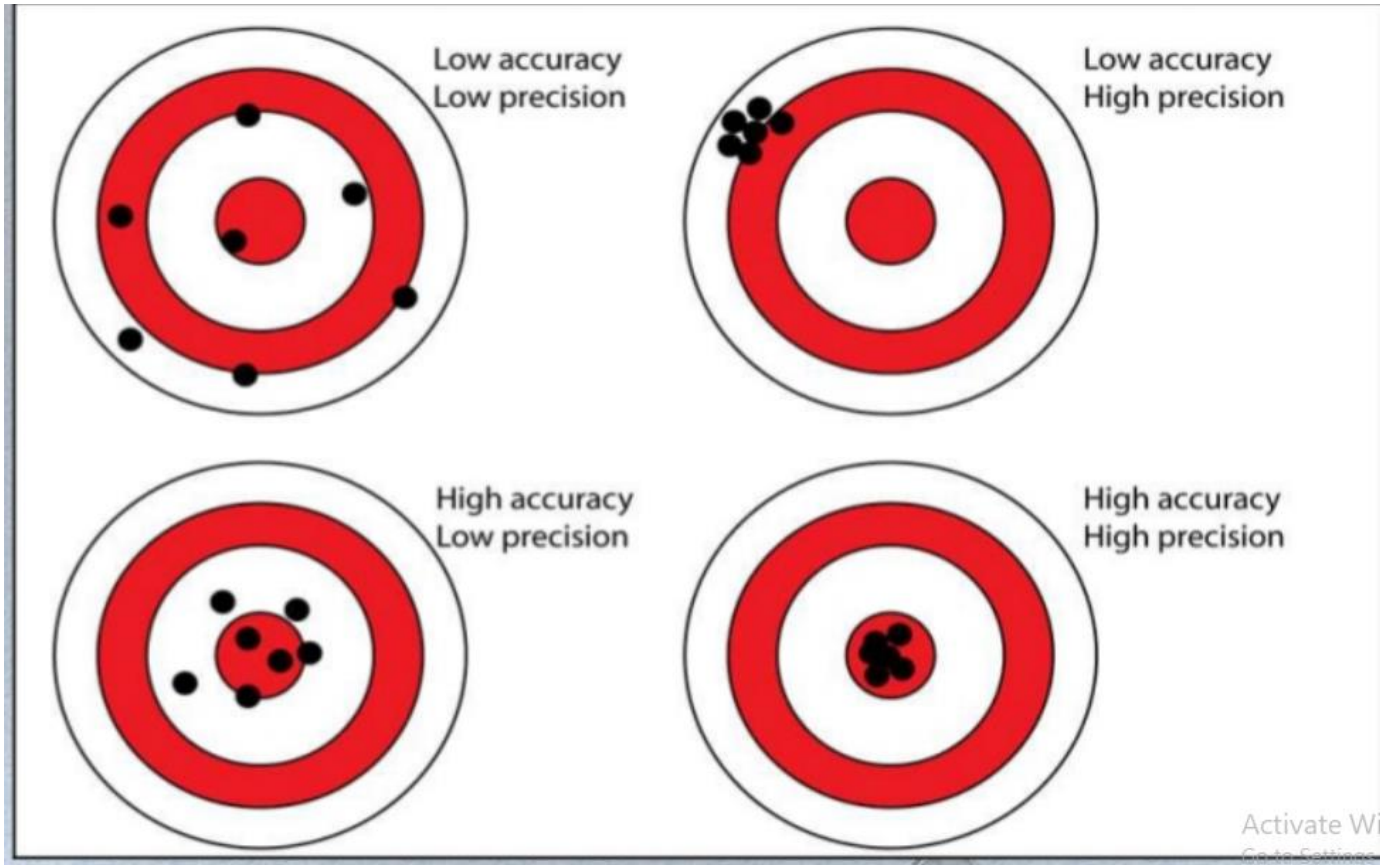
Difference between accuracy and precision:

S.No.	Precision:	Accuracy:
1.	It is nothing but the repeatability of the process.	Accuracy is the degree to which the measured value agrees with the true value of the measured quantity.
2.	Precision is the fineness of the instrument of the dispersion of the repeated readings.	Accuracy is the relative between the observed value and true values.
3.	Precision never designates accuracy.	Accuracy may designate precision.
4.	Standard Deviation is the index of precision. For less value of σ, more precise is the instrument.	The difference between the measured value and the true value is the error of the measurement. If the error is less, then the accuracy is more.


Low accuracy
Low precision
Low accuracy
High precision
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Low precision
High accuracy
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GENERALIZED MEASUREMENT SYSTEM

A MEASURING SYSTEM EXISTS TO PROVIDE INFORMATION ABOUT THE PHYSICAL VALUE OF SOME VARIABLE BEING MEASURED. IN SIMPLE CASES, THE SYSTEM CAN CONSIST OF ONLY A SINGLE UNIT THAT GIVES AN OUTPUT READING OR SIGNAL ACCORDING TO THE MAGNITUDE OF THE UNKNOWN

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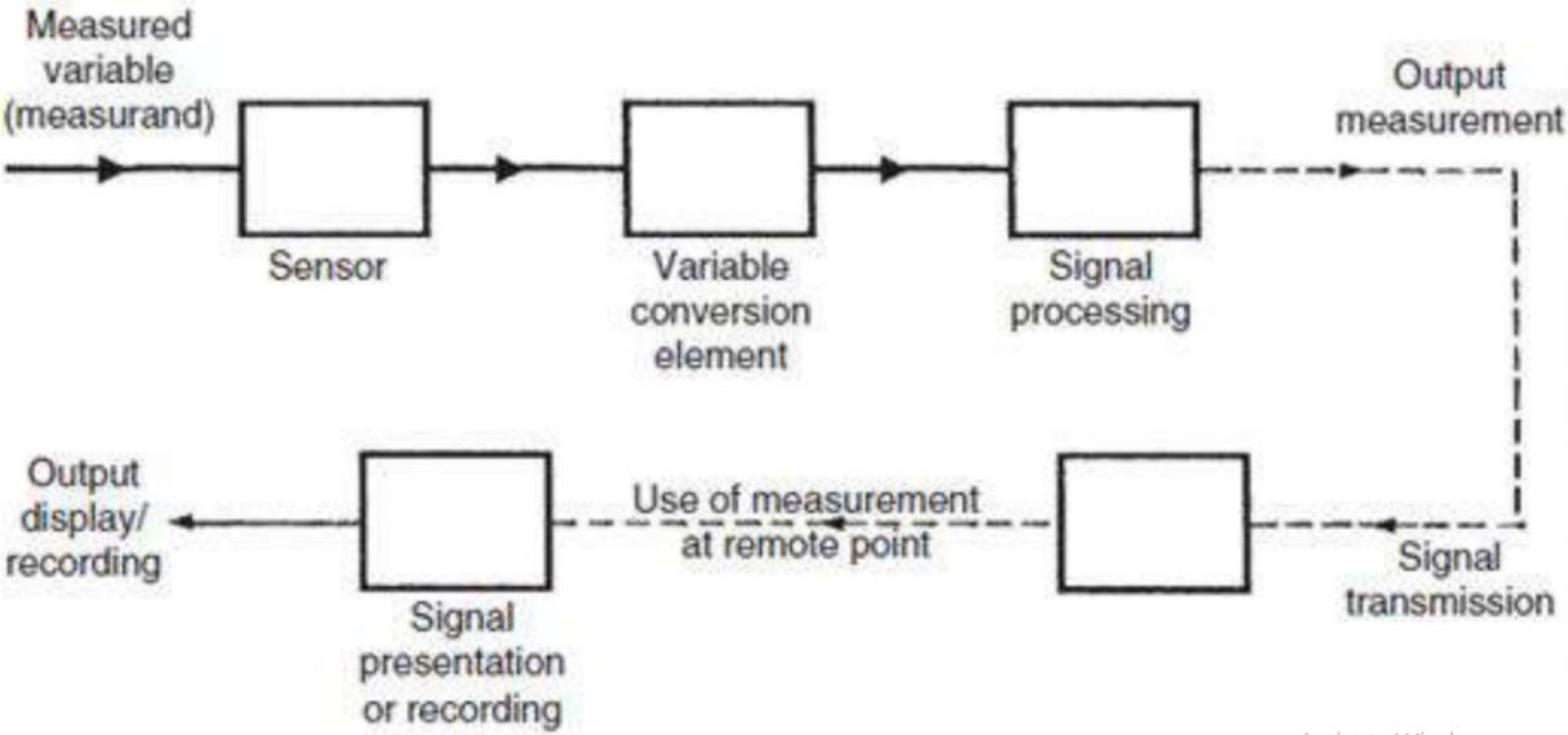


Fig 1.1 Generalised Measurement system

Errors in Measurement:

- **Error** is the difference between the measured value (V_m) and the true value (V_t) of a physical quantity. Accuracy of a measurement system is measured in terms of error.
- Static Error $E_s = V_m - V_t$
- Error may be positive or negative.
- If the instrument reads higher value than the true value, it is called as positive error.
- If the instrument reads lower value than the true value, it is called as negative error.
- **Types of Errors:**
- **Based on the measurement, Errors may be classified as:**

1. **Static Errors**
2. **Dynamic Errors**

Static Error:

- It results from the physical nature of the various components of the measuring system. It results from the environmental effect and other external influences on the properties of the apparatus.
- Types of Static Errors:

1. Reading Errors
2. Characteristic Errors
3. Environmental Errors
4. Loading Errors

Reading Error:

It is due to factors such as parallax error, interpolation, optical resolution(readability or output resolution). When there is error due to parallax, this can be eliminated by use of mirror behind the readout pointer or indicator. When there is error due to interpolation, it can be eliminated by increasing the optical resolution by using a magnifier over the scale in the vicinity of the pointer.

Characteristic Error:

It is defined as the deviation of the output of the measuring system under constant environmental conditions from the theoretically predicted performance. If the theoretical output is a straight line, then linearity error, hysteresis error, repeatability error and resolution errors are part of characteristic errors.

Environmental Errors:

It results from the effect of surrounding temperature, pressure and humidity on measuring system. It also results from the external influences like magnetic or electric fields, nuclear radiation, vibration or shock, periodic or random motion, etc., It can be reduced by controlling the atmosphere according to the essential requirements.

Loading Errors:

It results from the change in the measurand itself when it is being measured. It is the difference between the value of the measurand before and after the measurement system is measured. It is unavoidable and hence the measuring system should be selected such that its sensing element will minimize the instrument loading error.

Dynamic Error:

- It is caused by time variations in the measurand and results from the inability of a measuring system to respond faithfully to a time-varying measurand. They are generally due to the following factors: i) Inertia ii) Damping iii) Friction & iv) Other physical constraints in the sensing or readout or display system.
- Types of Dynamic Errors:

1. Systematic or controllable errors
2. Random errors

Systematic Errors: It is due to experimental mistakes. These are controllable in both their magnitude and sense. These can be determined and reduced if attempts are made to analyze them.

Types of Systematic Errors:

1. Calibration Errors
2. Ambient Conditions
3. Stylus Pressure
4. Avoidable Errors
5. Experimental Errors

General Care of Metrological Equipment

- The equipments are designed to fine limits of accuracy and is easily liable to be damaged by even-slight mishandling and such damage may not be noticeable. A great deal of careful handling is, therefore, required.

- As far as possible, the highly finished surfaces should not be touched by hand because the natural acids on the skin are likely to corrode the finished surface and also the temperature of body may upset the dimensions of the precision instruments.

- In order to overcome this many standard metrology laboratories recommend washing of hands thoroughly and coating them with a thin fily; of pure petroleum jelly before handling the instruments.

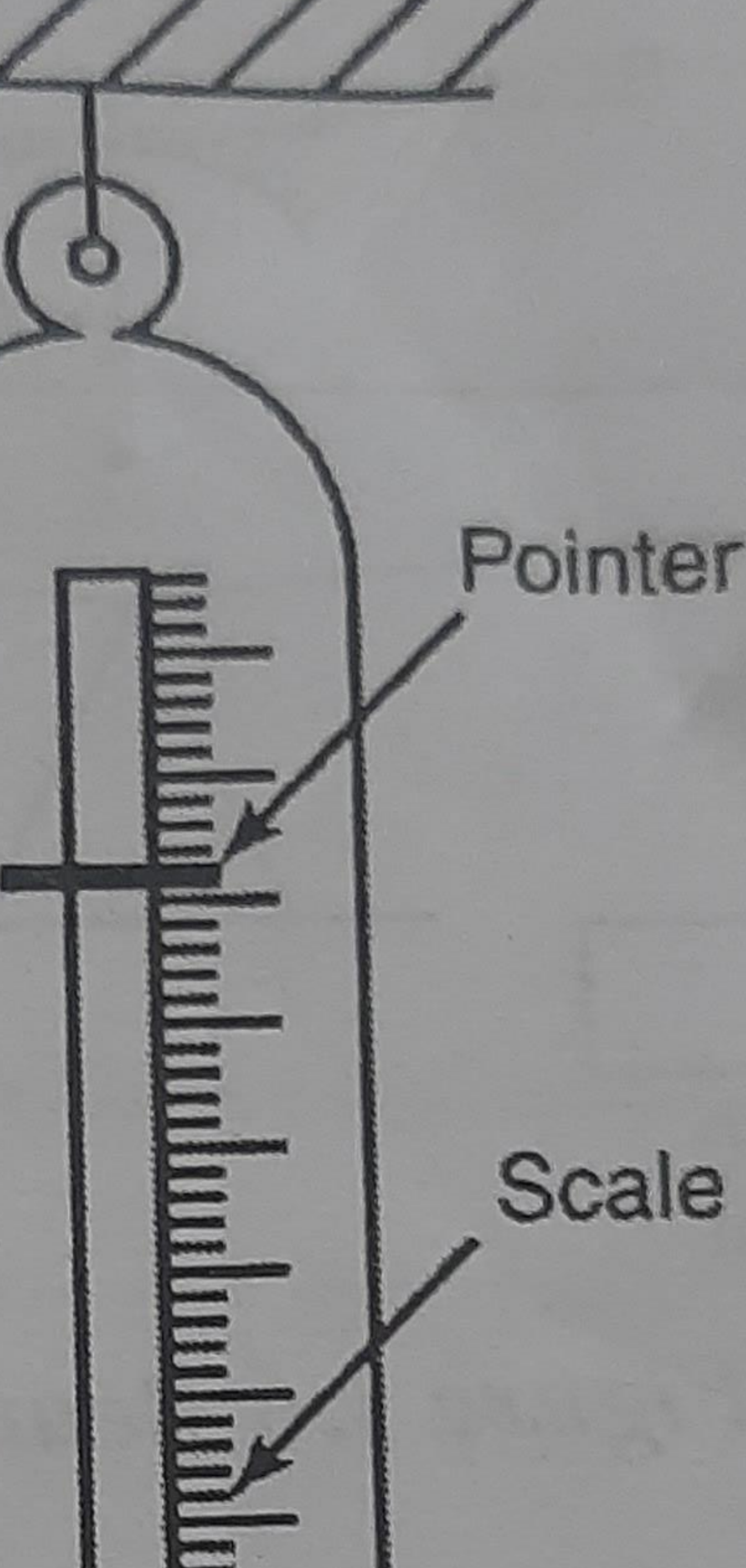
- When the equipment is not in use, it should be protected from atmospheric corrosion.

- As the standard temperature for measurement is 20°C, for very precise measurement the instruments and work pieces should be allowed to attain this temperature before use and the handling should be as little as possible.

MEASURING INSTRUMENTS

- Large number and variety of variables are involved in the measurement system.
- This variables may be constant with time or time varying.
- Measurement of weight – time constant
- Measurement of pressure in IC engine – time varying
- Types of instrument that are working in many different principles

- Classification of measuring instruments based on their application, mode of operation, manner of energy conversion and the nature of output signal
- Deflection and null type instruments
- Analog and digital instruments
- Active and passive type instruments
- Automatic and manually operated instruments
- Absolute and secondary instruments
- Contacting and non contacting instruments
- Intelligent instruments


Pointer
Scale

Unit 2

- Linear and Angular Measurement

Dimensions

- A very common measurement is that dimensions, i.e., length, width, height of an object

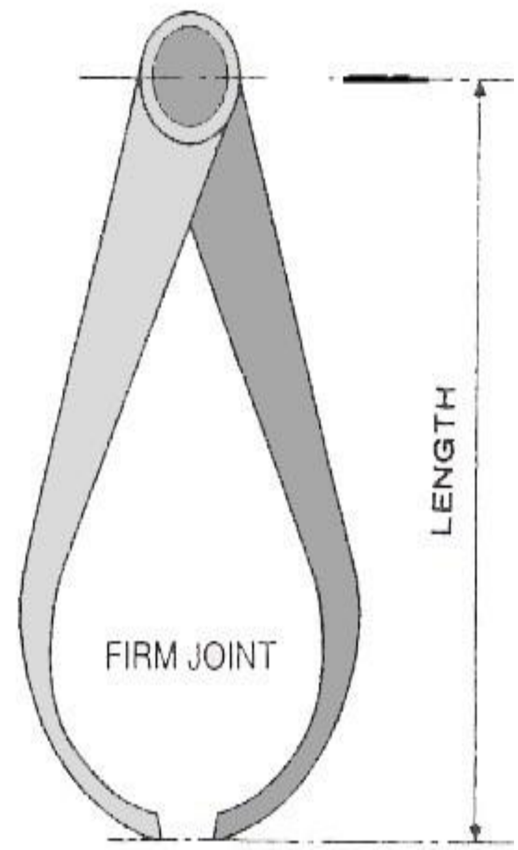
- Dimensions of the measuring instruments are classified as follows
  - Low resolution devices (up to 0.25mm)
  - Medium resolution devices (up to 0.0025mm)
  - High resolution devices (less than microns)

Low resolution devices

- Steel rule

- Steel rule with assistance of
  - Calipers
  - Dividers &
  - Surface gauges

- Thickness gauges



Medium resolution devices

- Micrometer
- Vernier calipers
- Dial indicators
- Microscope

High resolution devices

- Gauge blocks
- Gauge block with assistance of
  - Mechanical comparator
  - Electronic comparator
  - Pneumatic comparator
  - Optical flats

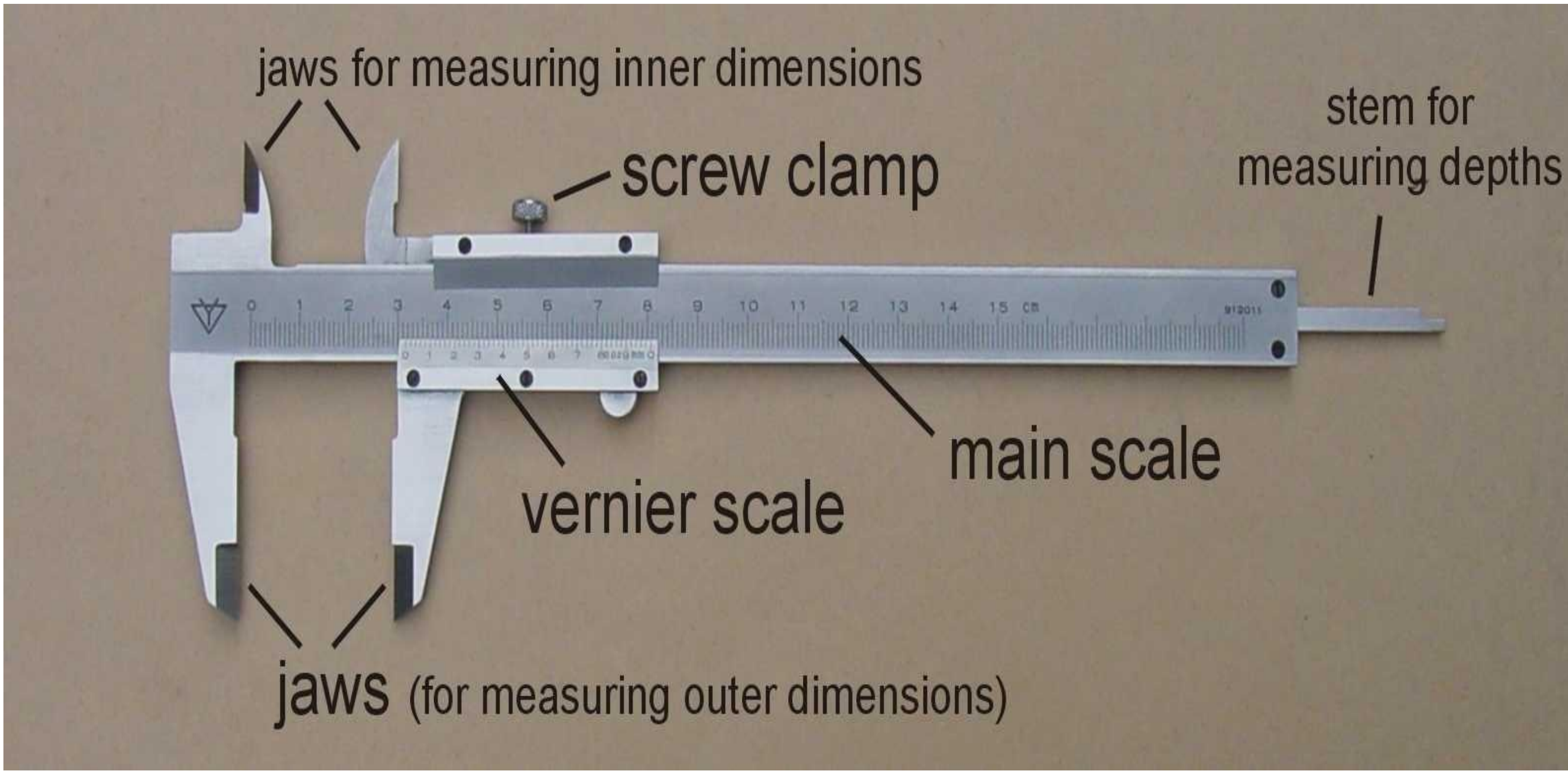
Linear Measuring Instruments

- Vernier caliper
- Micrometer
- Slip gauge or gauge blocks
- Optical flats
- Interferometer
- Comparators

Vernier caliper

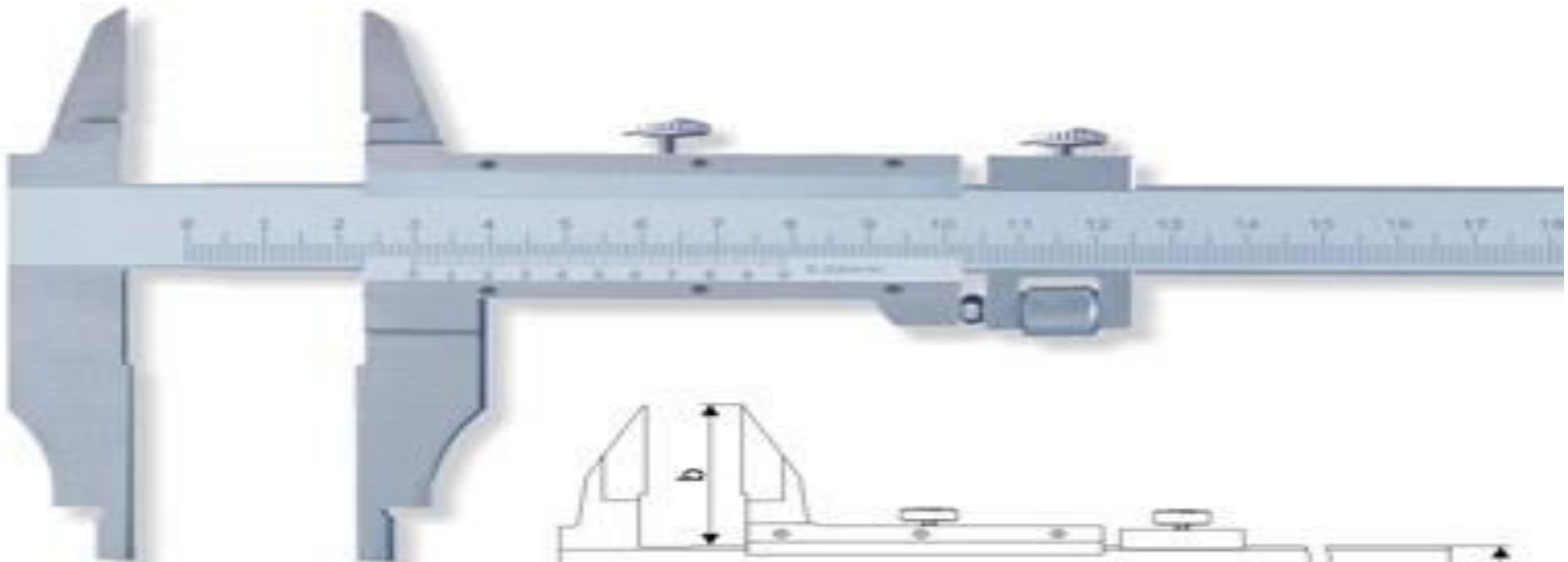
- Components of vernier calipers are
  - Main scale
  - Vernier scale
  - Fixed jaw
  - Movable jaw
- Types of vernier calipers
  - Type A vernier caliper
  - Type B vernier caliper
  - Type C vernier caliper

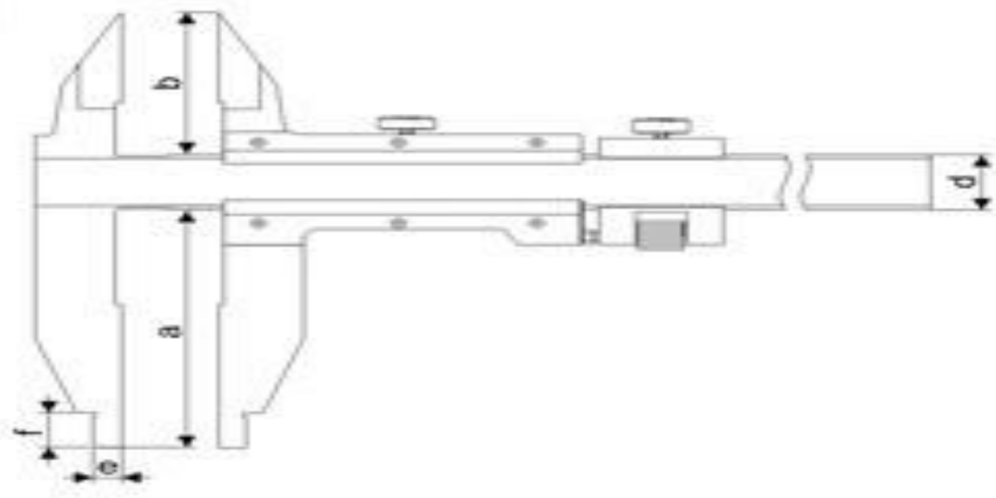
Type A Vernier Caliper



Type B Vernier Caliper

Type C Vernier Caliper





Vernier caliper

VERIER CALIPER WITH 0.02MM LEAST COUNT IS GENERLY USED IM WORK SHOP.

In this Vernier caliper main scale division (49mm) are divided in to 50 equal part in the Vernier scale.

1 main scale division =1 mm

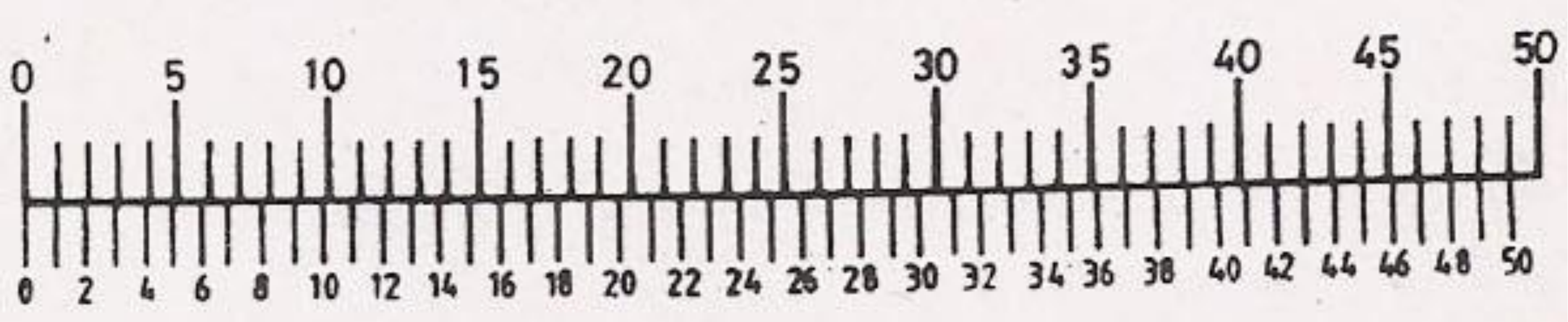
(MSD)

1.Vernier scale division =49\50 mm

(VSD)

Least count is 1mm – 49\50 =1\50 mm

THE DIFFERENCE BETWEEN 1.MSD and 1. VSD=0.02MM

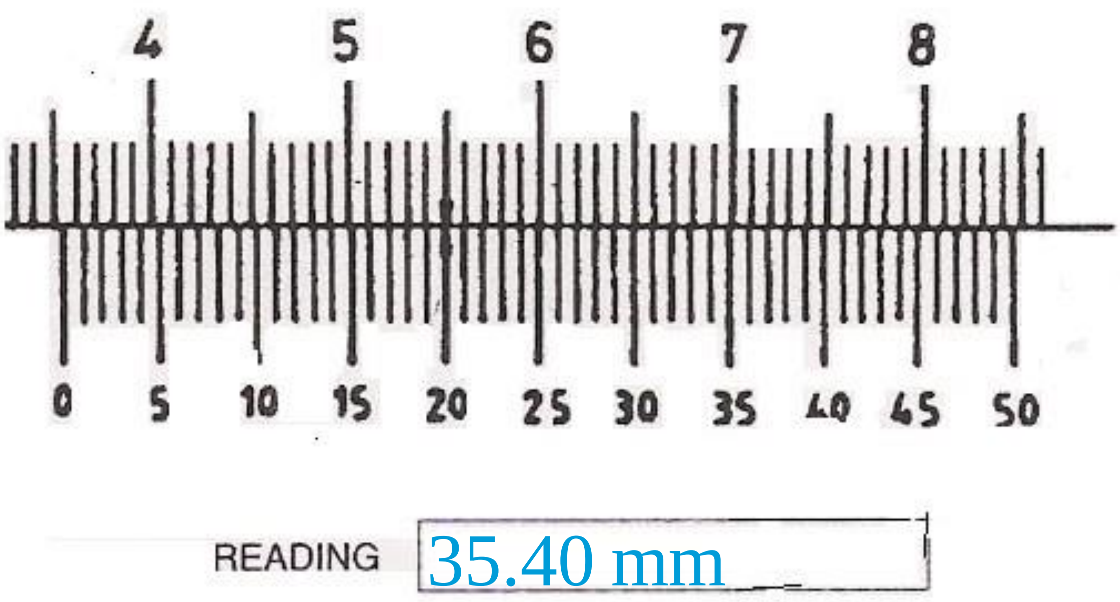


Example

Main scale reading =35mm

The vernier division coinciding with the main scale is the 20th division. Value=20 multiplied by 0.02=0.40mm.

Total reading is 35mm+0.40= 35.40mm

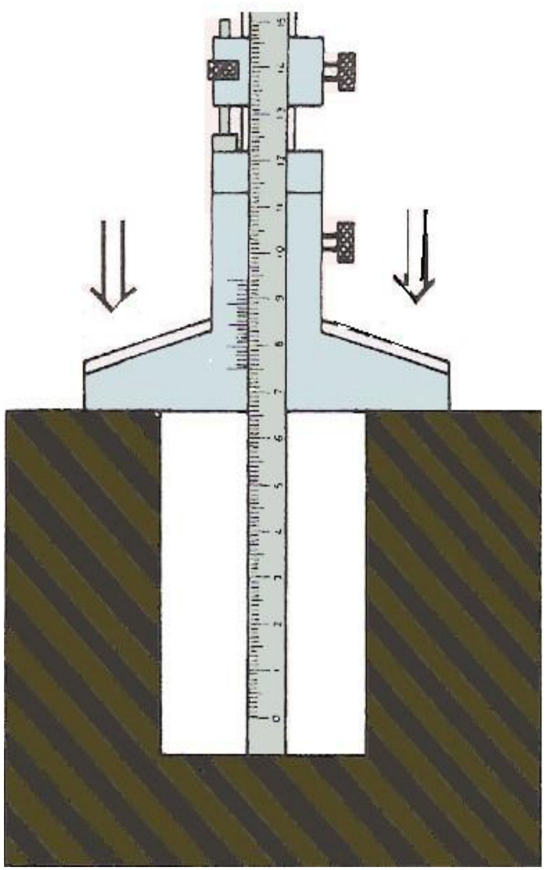


Vernier Depth Gauge

A vernier depth is very commonly used precision instrument for measuring depth of holes recesses, slot and step.

Its construction and method of reading are similar to those of a vernier caliper.

VERNIER DEPTH GAUGE



VERNIER HEIGHT GAUGE

The main parts of a vernier height gauge and their function are given.

1.base

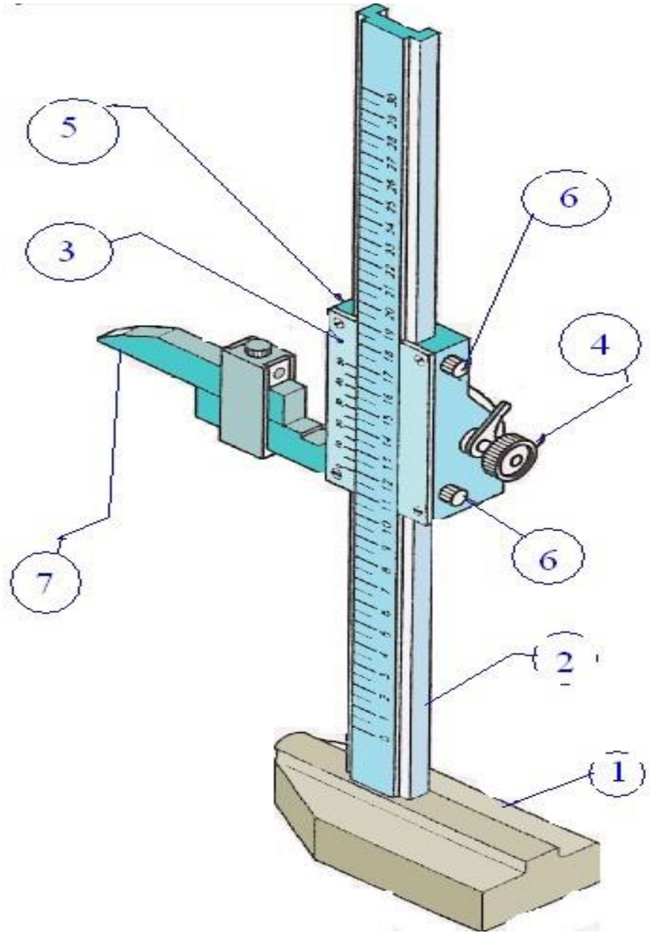
2.beam 3.vernier slide

4.fine setting device

5.vernier plate

6.locking screws

7.scriber



MICRO METER

- A micro meter is a precision instrument used to measure a job, generally within an accuracy of 0.01mm.Micrometer used to take the outside measurements are know as outside micrometer.

PARTS OF MICROMETER

Frame

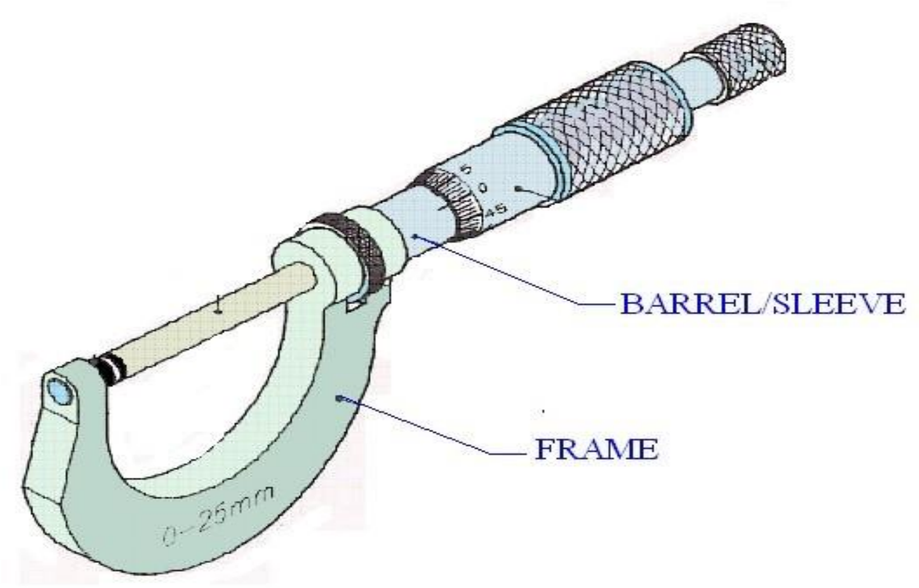
Anvil and spindle

Screwed spindle

Graduated sleeve or barrel

Ratchet or friction stop

Spindle clamp



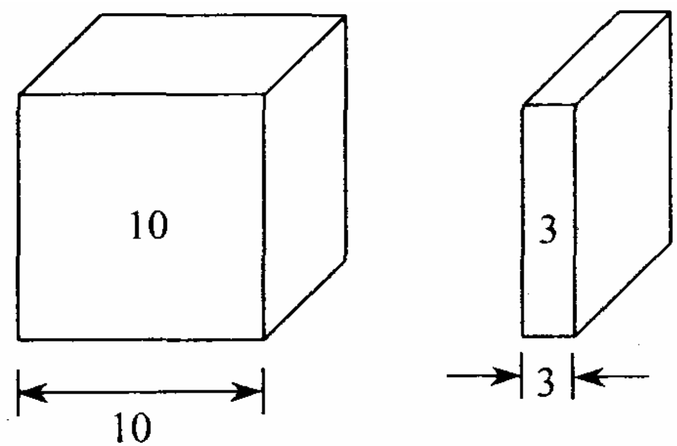
Interval measurements

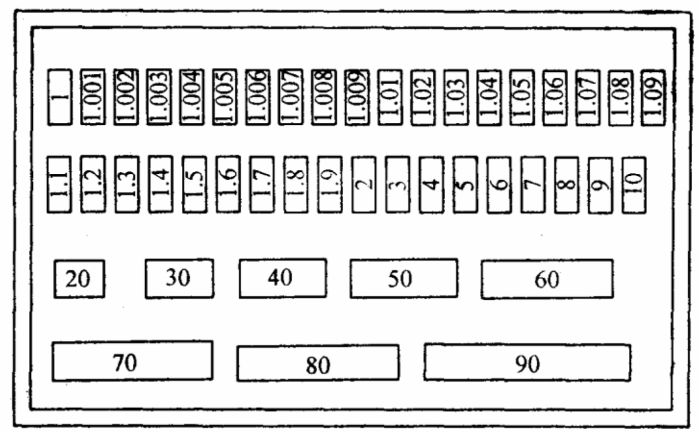
- Slip gauges
- Interferometer
- Optical flats and limit gauges
- Comparators

SLIP GAUGE

Slip gauges are used as measuring blocks.

It is also called as precision gauge blocks.





CLASSIFICATION OF SLIP GAUGES:

Slip gauges are classified into various types according to their use as follows:

1) Grade 2
2) Grade 1
3) Grade 0
4) Grade 00
5) Calibration grade.

1) Grade 2:

It is a workshop grade slip gauges used for setting tools, cutters and checking dimensions roughly.

2) Grade 1:

The grade I is used for precise work in tool rooms.

3) Grade 0:

It is used as inspection grade of slip gauges mainly by inspection department.

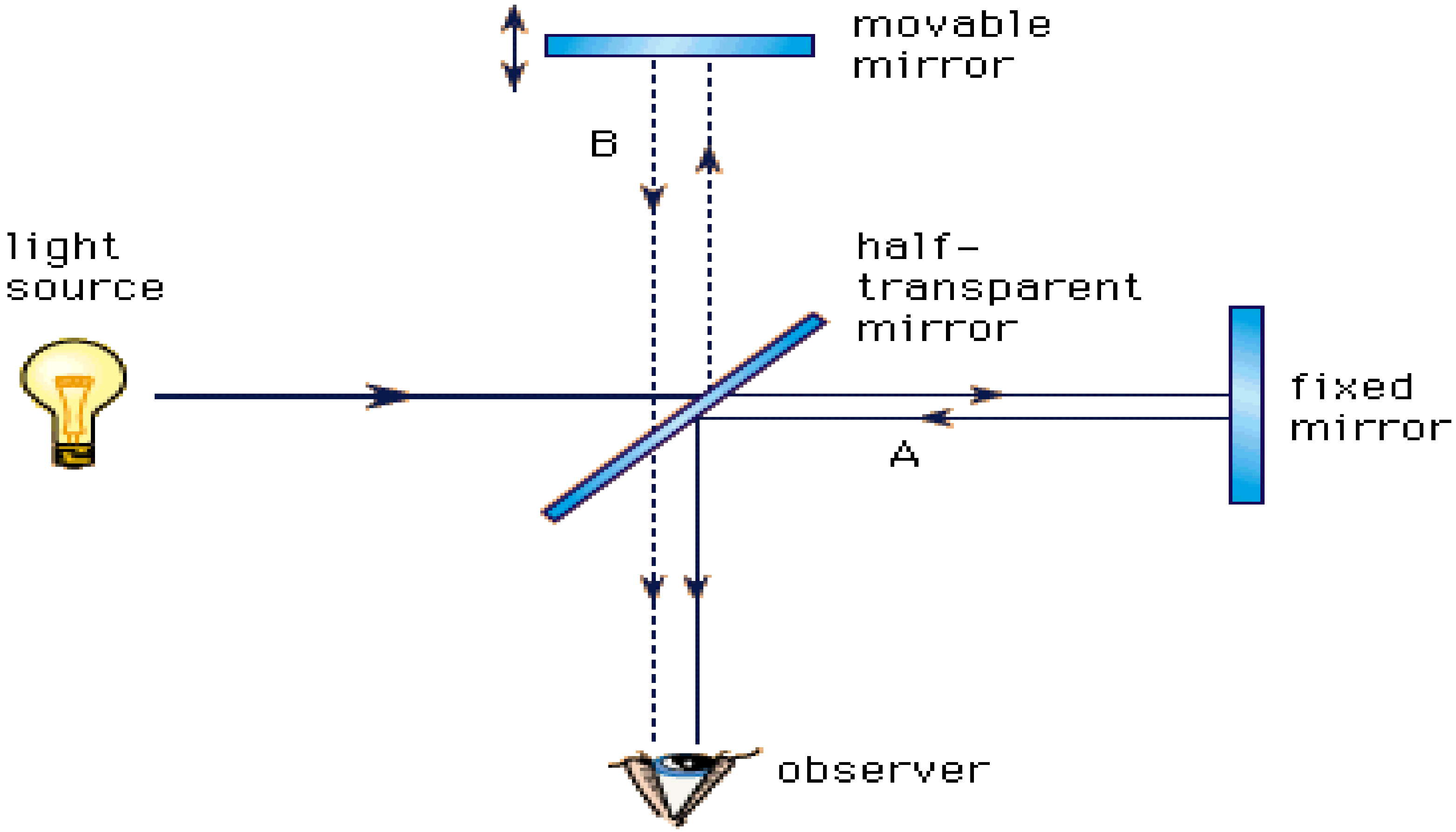
4) Grade 00:

Grade 00 mainly used in high precision works in the form of error detection in instruments.

5) Calibration grade:

The actual size of the slip gauge is calibrated on a chart supplied by the manufactures.

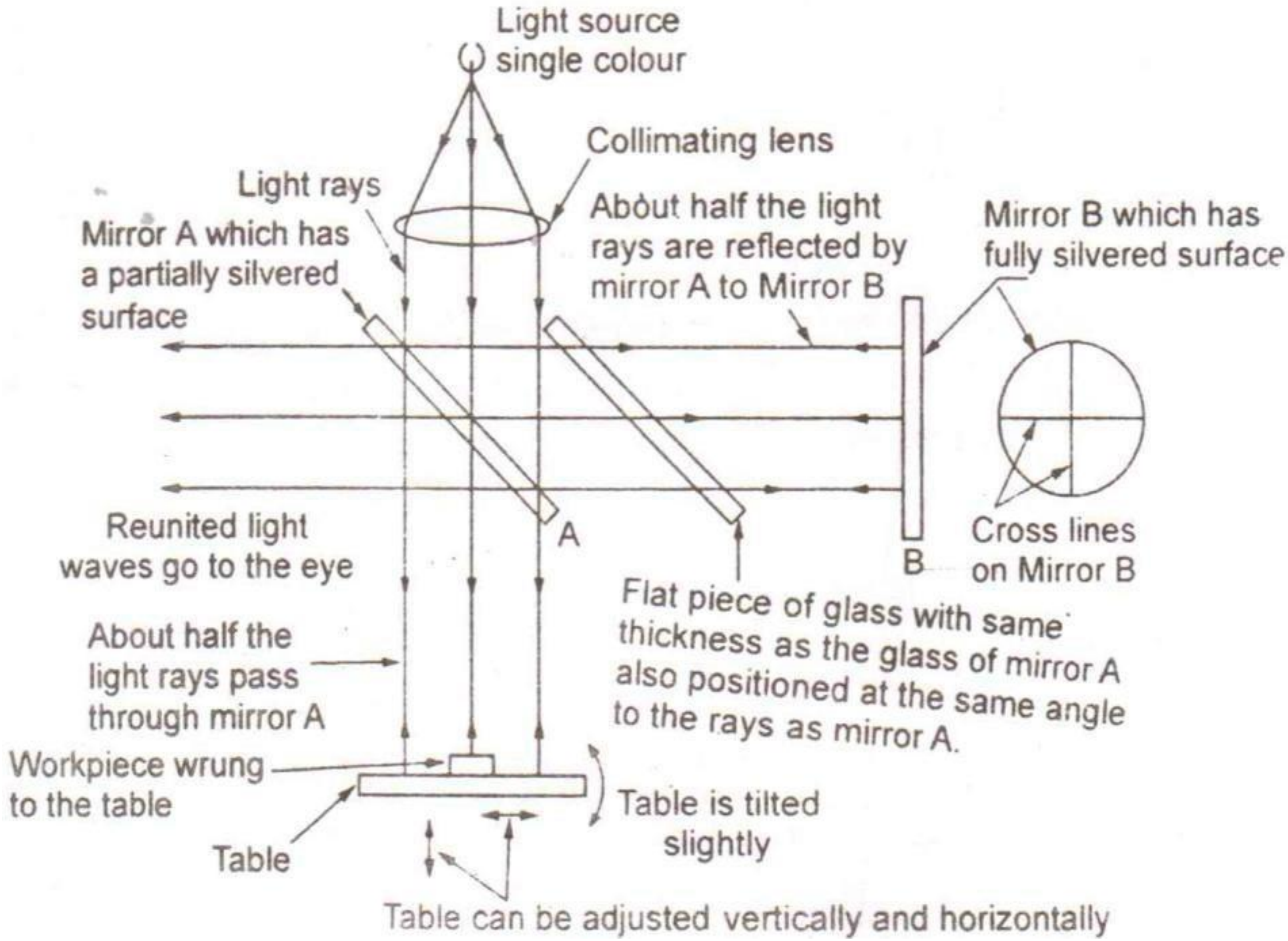
Interferometer



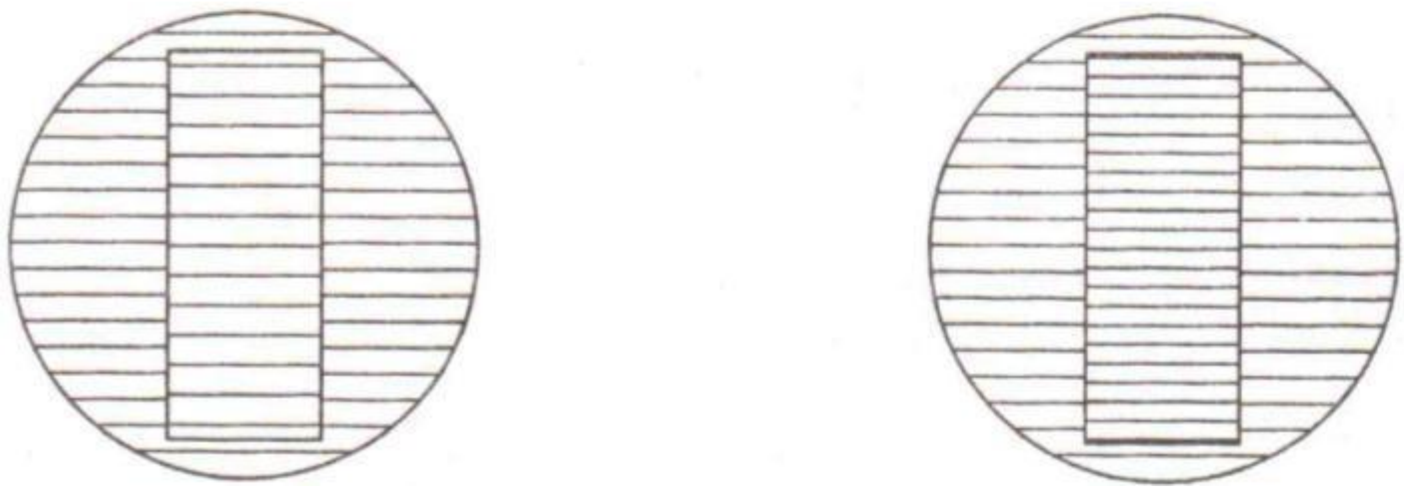
Principle

- Interferometers are optical instruments used for measuring flatness

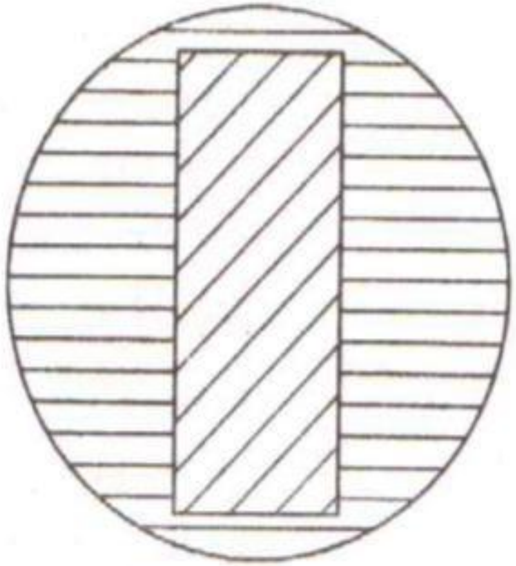
- Determining minute differences in length by direct reference to the wavelength of light.


Light source
single colour
Collimating lens
Light rays
About half the light
rays are reflected by
mirror A to Mirror B
Mirror B which has
fully silvered surface
Mirror A which has
a partially silvered
surface
A
B
Reunited light
waves go to the eye
Cross lines
on Mirror B
Flat piece of glass with same
thickness as the glass of mirror A
also positioned at the same angle
to the rays as mirror A.
About half the
light rays pass
through mirror A
Workpiece wrung
to the table
Table is tilted
slightly
Table
Table can be adjusted vertically and horizontally

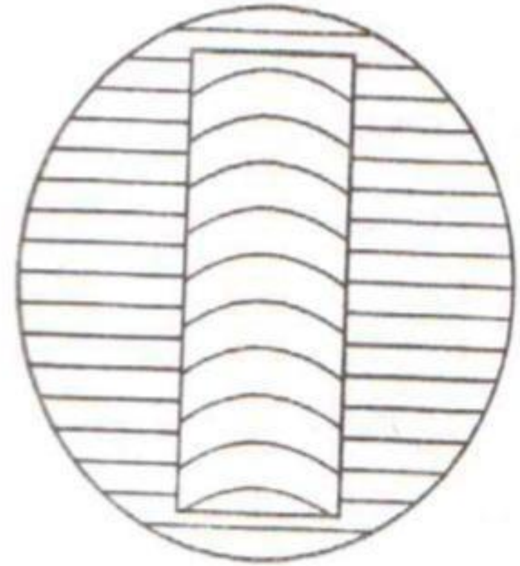
Fringes



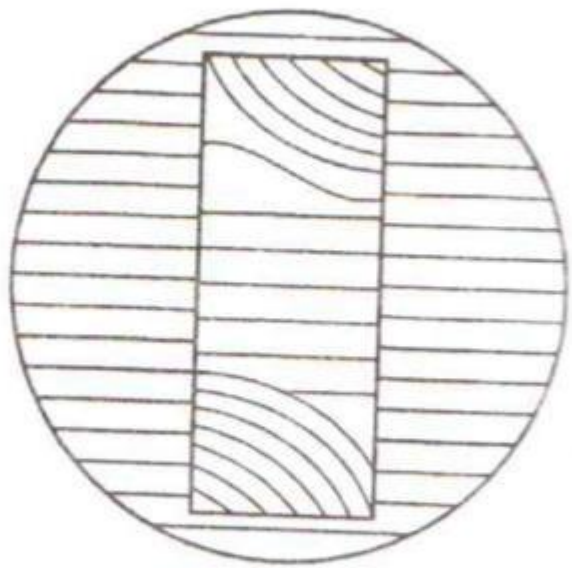
Fringes



a



b

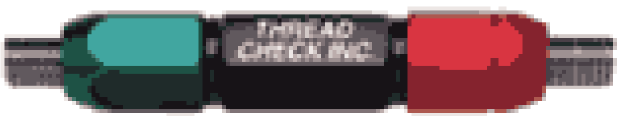


c

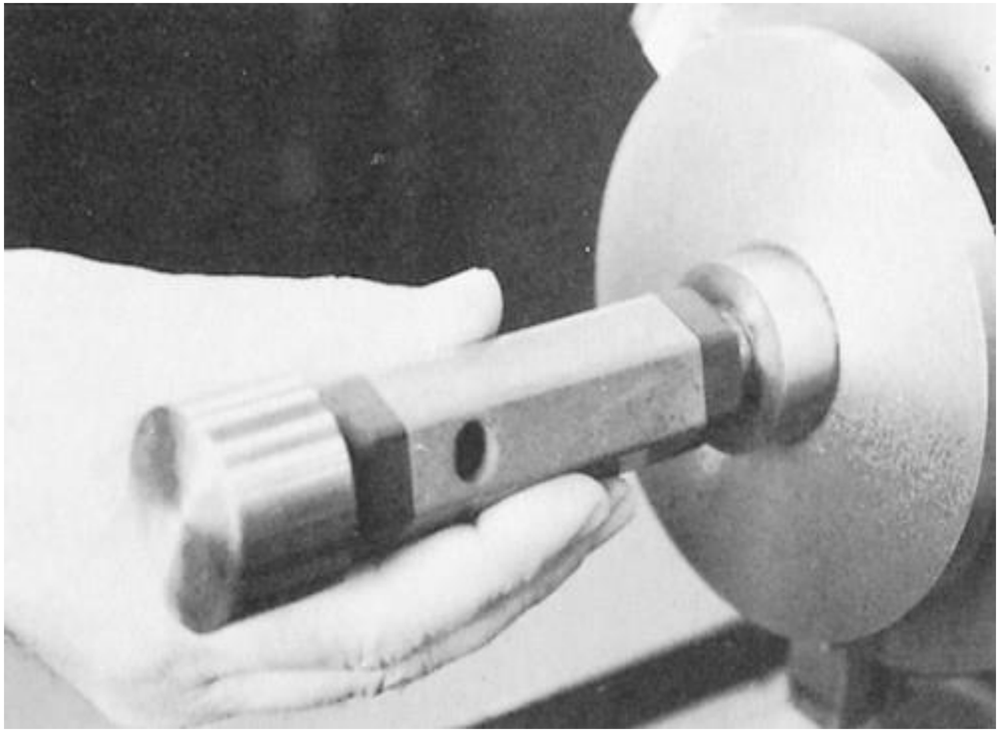
LIMIT GAUGES:

- A limit gauge is not a measuring gauge. Just they are used as inspecting gauges.
  - The common types are as follows:
    - 1) Plug gauges.
    - 2) Ring gauges.
    - 3) Snap gauges.

Cylindrical Plug Gauges



Cylindrical Plug gauge



Plain Ring Gauges

- Used to check outside diameter of pieces
- Ground and lapped internally to desired size
  - Size stamped on side of gauge
- Outside diameter knurled and "no-go" end identified by annular groove on knurled surface
- Precautions and procedures similar to those outlined for a plug gauge

Plain Ring gauges

Taper Plug Gauges

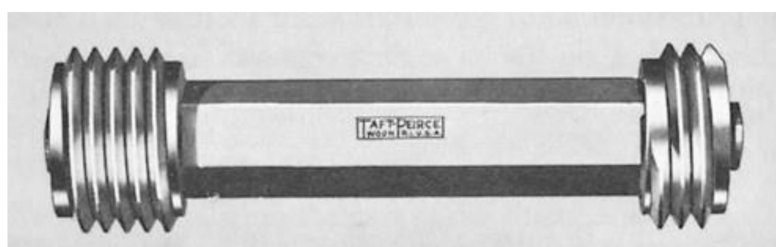
- Used to check size of hole and taper accuracy
- Made with standard or special tapers
- Some have "go" and "no-go" rings scribed
  - gauge fits into hole between two rings means within required tolerance

Taper Plug and Ring Gauges

Thread Plug Gauges

- Used for checking internal threads of the "go" and "no-go" variety
- Based on same principle as cylindrical plug gauges
- "go" end (longer end)
  - Should be turned in flush to bottom of hole
- "no-go" end
  - Should just start into hole and become snug before third thread enters

Thread Plug Gauges



Thread Ring Gauges

Snap Gauges

- One of most common types of comparative measuring instruments
- Faster to use than micrometers
- Limited in their application
- Used to check diameters within certain limits by comparing part size to preset dimension of snap gauge

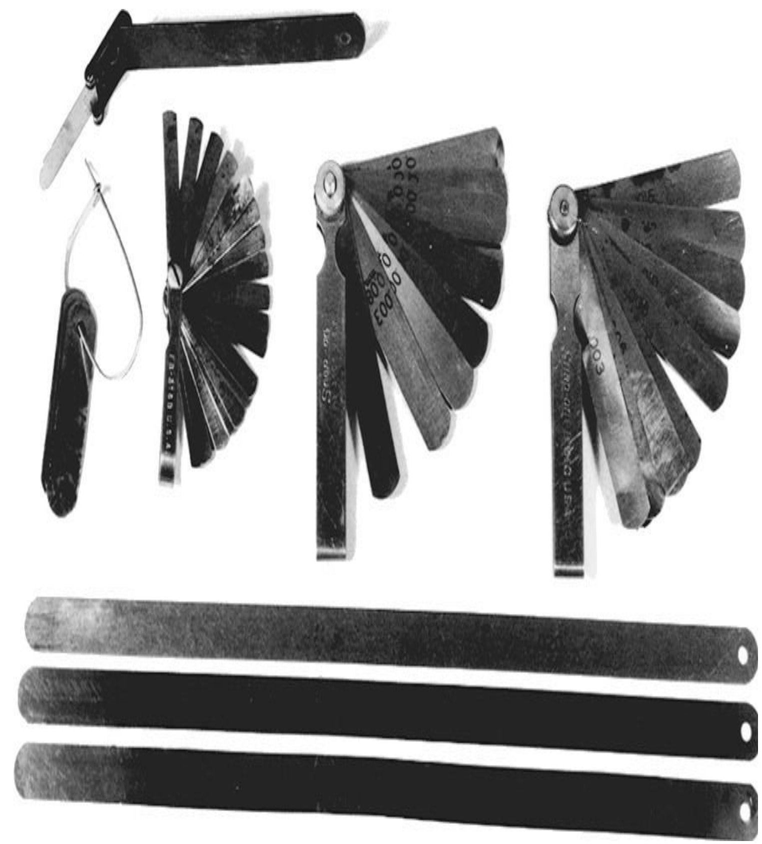
Snap Gauges

- Have C-shaped frame with adjustable gauging anvils or rolls set to "go" and
of the part
- Several styles

(a) (b) (c)

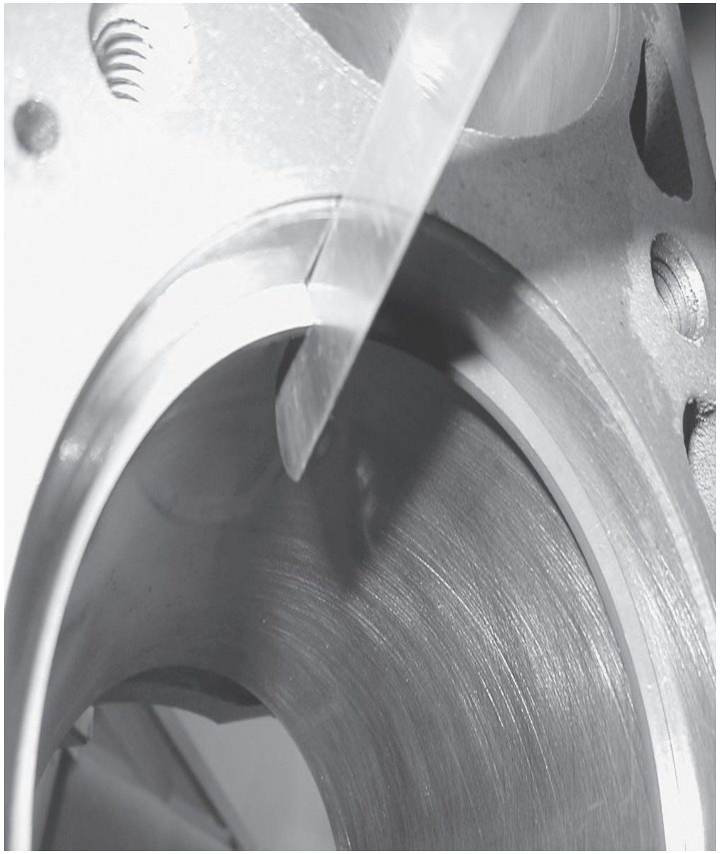
FEELER GAUGE

- A **feeler gauge** (also known as a **thickness gauge**) is an accurately manufactured strip of metal that is used to determine the gap or clearance between two components.



FEELER GAUGE

- A feeler gauge can be used to check the following:
  - Piston ring gap
  - Piston ring side clearance
  - Connecting rod side clearance



Radius Gauge

- A **radius gauge** is a tool used to measure the radius of an object.

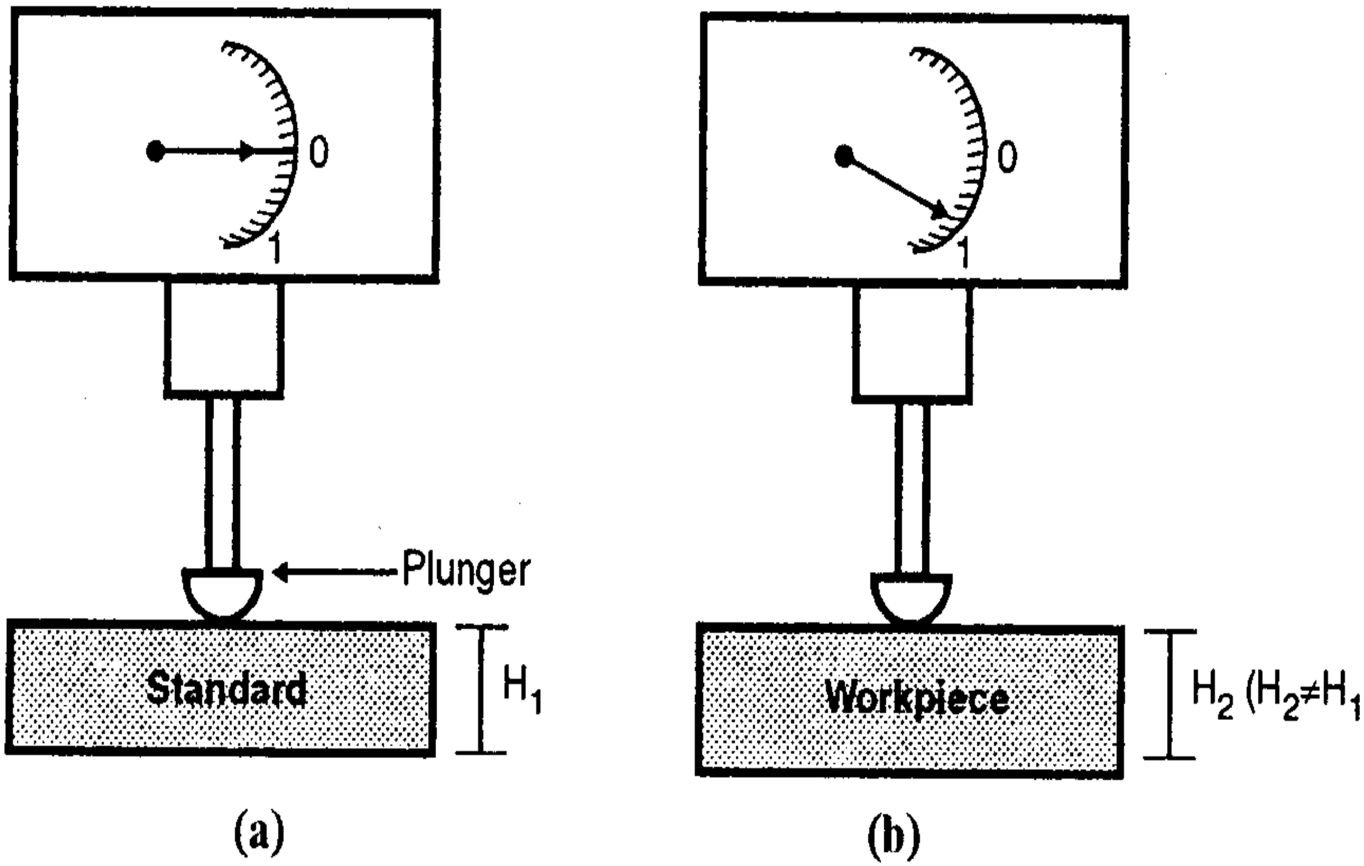
Thread Pitch Gauge

- It used to quickly determine the pitch of various threads by matching the teeth on the leaves with teeth on the work.

Comparators

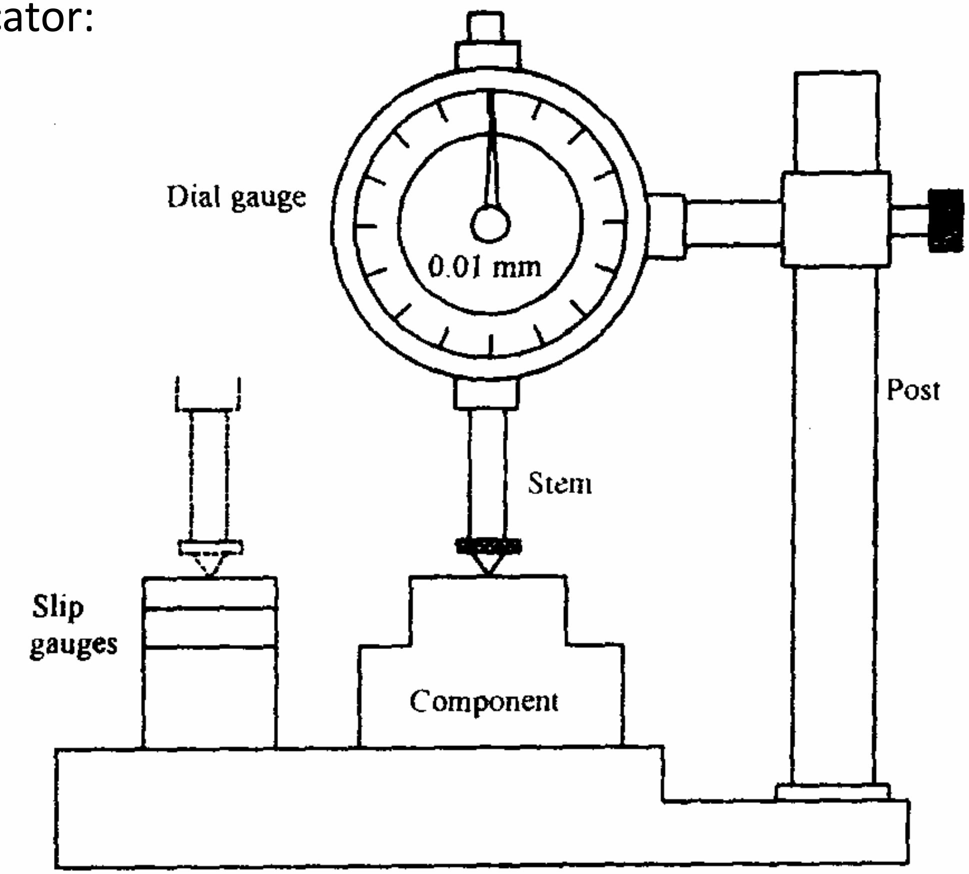
- Mechanical comparators
- Electrical comparators
- Optical comparators
- Pneumatic comparators

Mechanical comparators



MECHANICAL COMPARATORS:

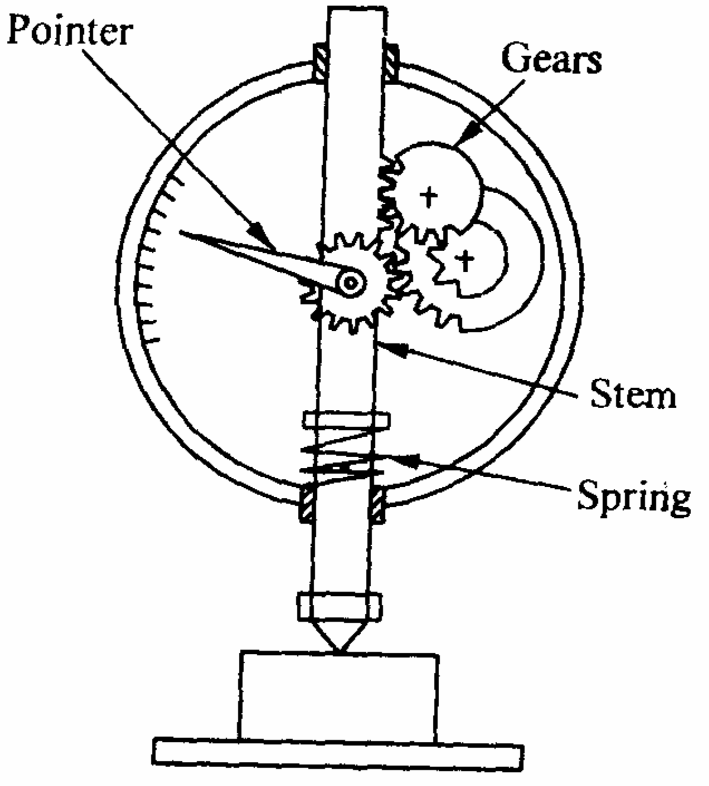
Dial indicator:



The Principle of Operation

- “A very slight upward pressure on the spindle at the contact plunger is magnified through a system of gears and levers and is indicated on dial by pointer and scale.”
- The dial has a scale division value of 0.01mm usually. The whole arrangement is housed in a metal case for its protection. Dial is graduated into 100 divisions

Dial gauges are usually available having dial graduation of 0.01 mm or even 0.02 mm. Some sensitive types of dial gauge have graduation of 0.002 mm



- **The dial indicator is used for:**
- (i) Determining the error in geometrical form, say, taper, roundness, ovality etc.
- (ii) Determining the errors is surfaces, say alignment, Parallelism, squareness etc.
- (iii) Used for comparison of two heights or distance within small limits
- (iv) Used for compression and tension testing of materials.

- **Practical Application:**
- (i) To check the trueness of milling machine arbers.
- (ii) To check the parallelism of shape machine ram with surface.
- (iii) To check the alignment of lathe machine centers by using a bar between centers.

ELECTRICAL COMPARATOR

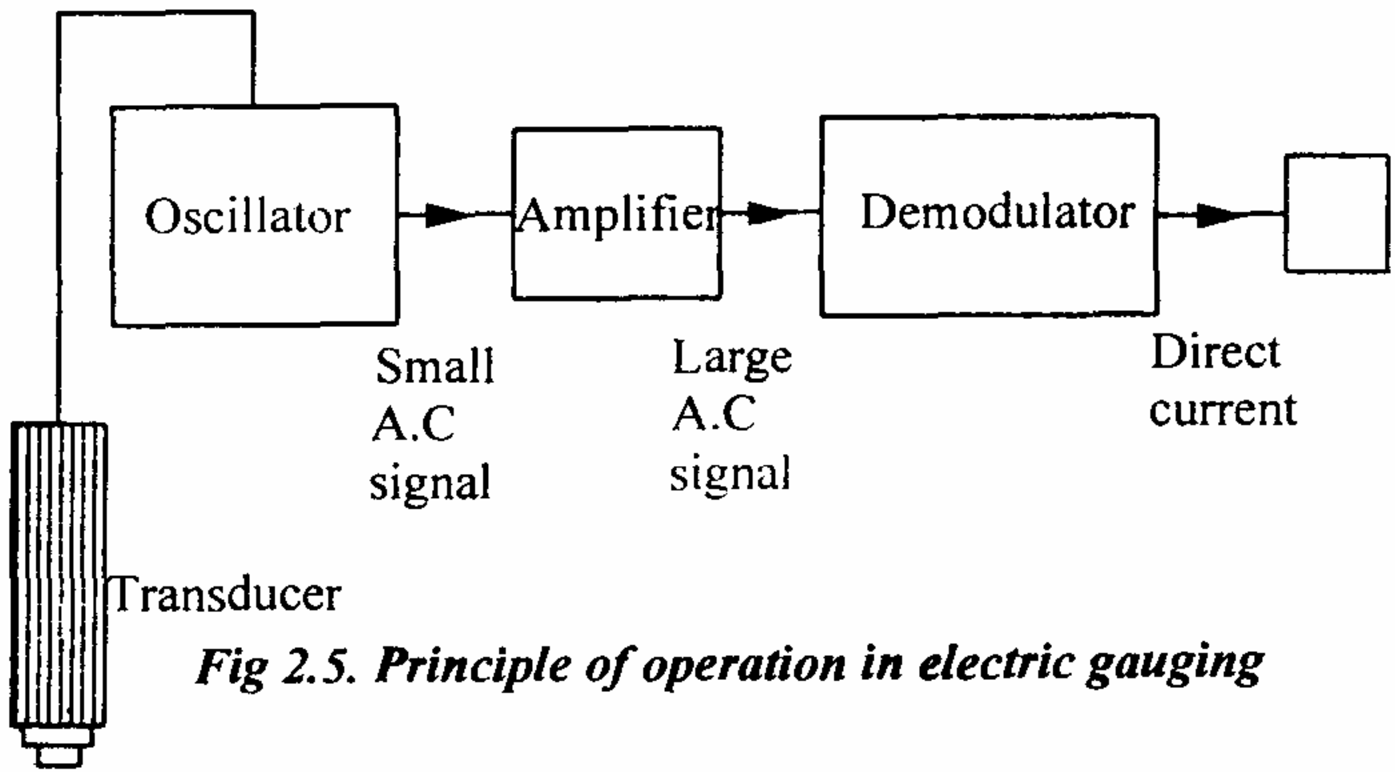


Fig 2.5. Principle of operation in electric gauging

Electrical Comparators

- An Electrical comparator employs electrical means to get the magnification. In this comparator the movement of the measuring contact plunger is converted into an electrical signal.
- The electrical signal is recorded by an instrument which can be calibrated in terms of plunger movement.

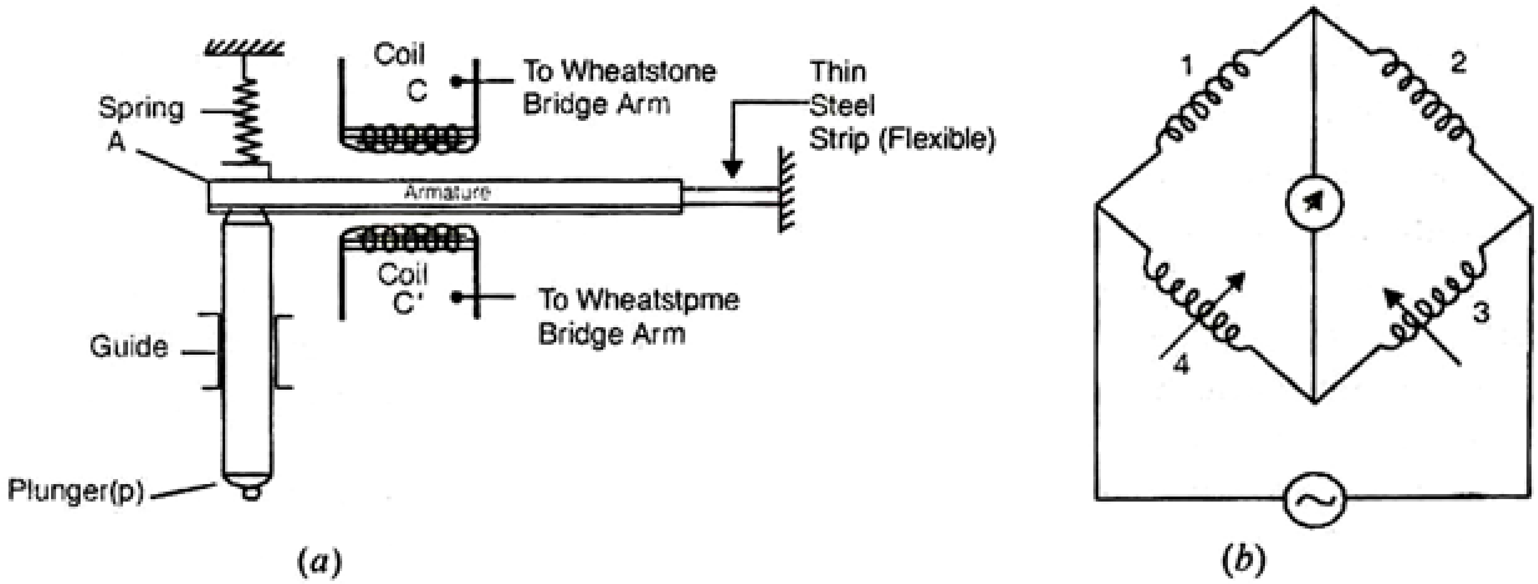


Fig. 1.13. Principle of electrical comparator.

- **(i) Measuring Probe (Plunger):**
- This is in direct contact of the component being checked.
- **(ii) Amplifier and Indicating Unit:**
- Amplifier boost up the electrical signals obtained and gives to indicating unit. Indicating unit indicates the variation of dimensions if any by movement of pointer on a calibrated scale.
- **(iii) Power Unit:**
- Power unit gives the power to the wheat-stone bridge to balance it while setting the pointer to zero with respected to standard component.
- **(iv) Base and Standard Unit:**
- These provide hold and support to all the other units. Other than four basic units, a spring is provided to control the contact pressure. A thin flexible steel strip also provided as shown in Figure.

- an armature supported on thin flexible steel strip is suspended between two coils C and C. When the distance of the armature from two coils is equal, the Wheatstone bridge is balanced and no current flows through the galvanometer.
- Little movement of the measuring plunger unbalances the bridge resulting in the flow of current through the galvanometer. Galvanometer scale is calibrated to give the movements of the plunger.

- **Advantage of Electrical Comparators:**
- (i) High Degree of Reliability
- (ii) Remote Measurement:
- (iii) High Magnification:
- (iv) Not Sensitive to Vibrations:
- **Disadvantage of Electrical Comparators:**
- (i) High Cost:
- (ii) External Power Source:
- Heating of Coils:

Optical Comparators:

- There is no pure optical comparator but large magnification is obtained by use of optical principle in optical comparators.
- A mechanical instrument also contributes quite a lot for the overall magnification. Hence sometimes it is referred as ‘Mech-optical comparator’.
- Magnification in case of optical comparators is obtained with the help of light beams which has an advantage of being straight and weightless. Optical comparators have their own built in light source.

If a ray of light AC strikes a mirror, it is reflected as ray CO such that:

$\angle ACN = \angle NCO$

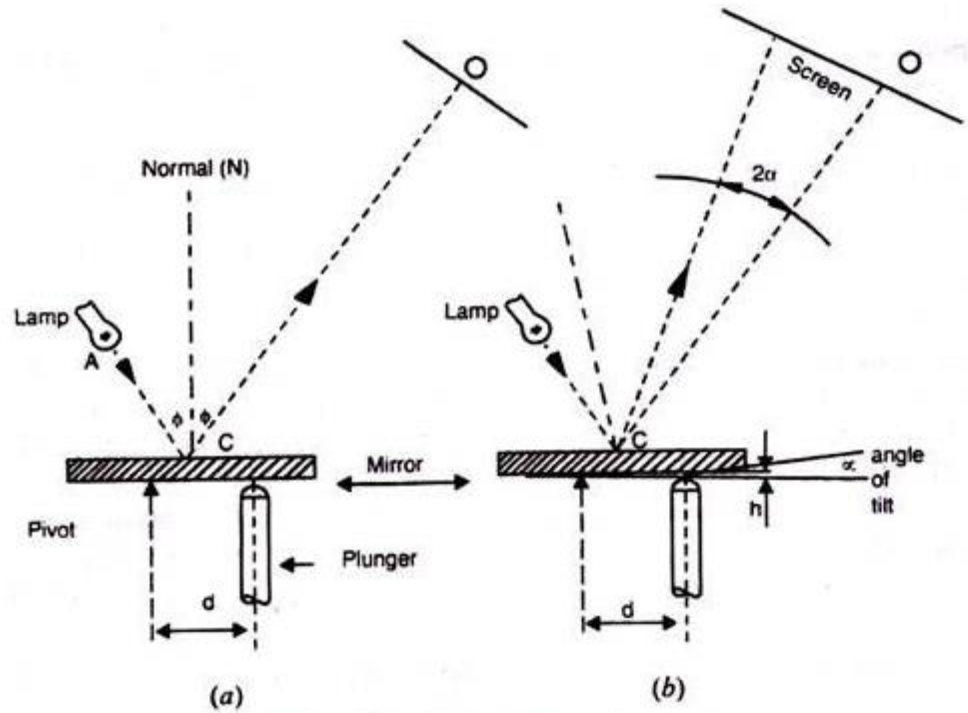


Fig. 1.14. Principle of the optical lever.

- If the mirror is tilted through an angle a, the reflected ray of light has moved through an angle of 2a.
- In optical comparators, the minor is tilted by the measuring plunger movement and the movement of reflected light is recorded as an image on a screen.
- Fig. 1.15 shows the working principle of an optical-mechanical comparator in which both mechanical and optical levers are used.

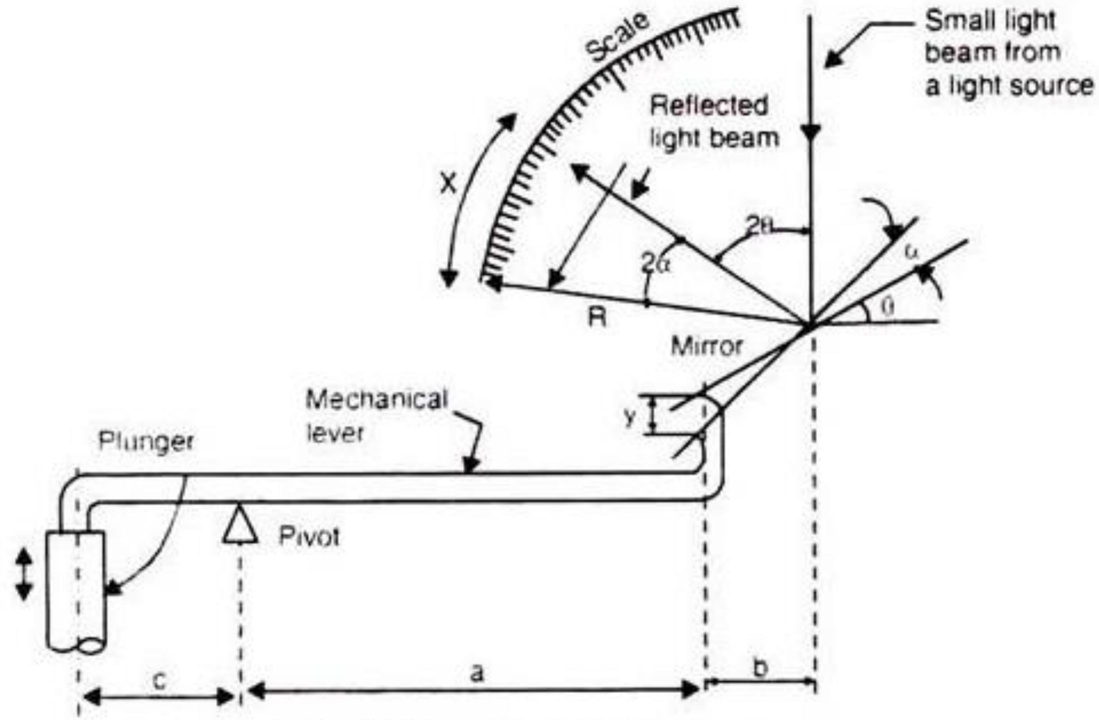


Fig. 1.15. An Optical Comparator.

- **Magnification:**
- The magnification of optical comparator is defined as "the ratio between distance moved by the indicating pointer (beam) and the displacement of plunger".
- The Magnification of optical comparators is usually 1000:1, with measuring range of plus and minus 0.075 mm.

$$\text{Total Magnification} = \text{Mechanical Magnification} \times \text{Optical Magnification}$$

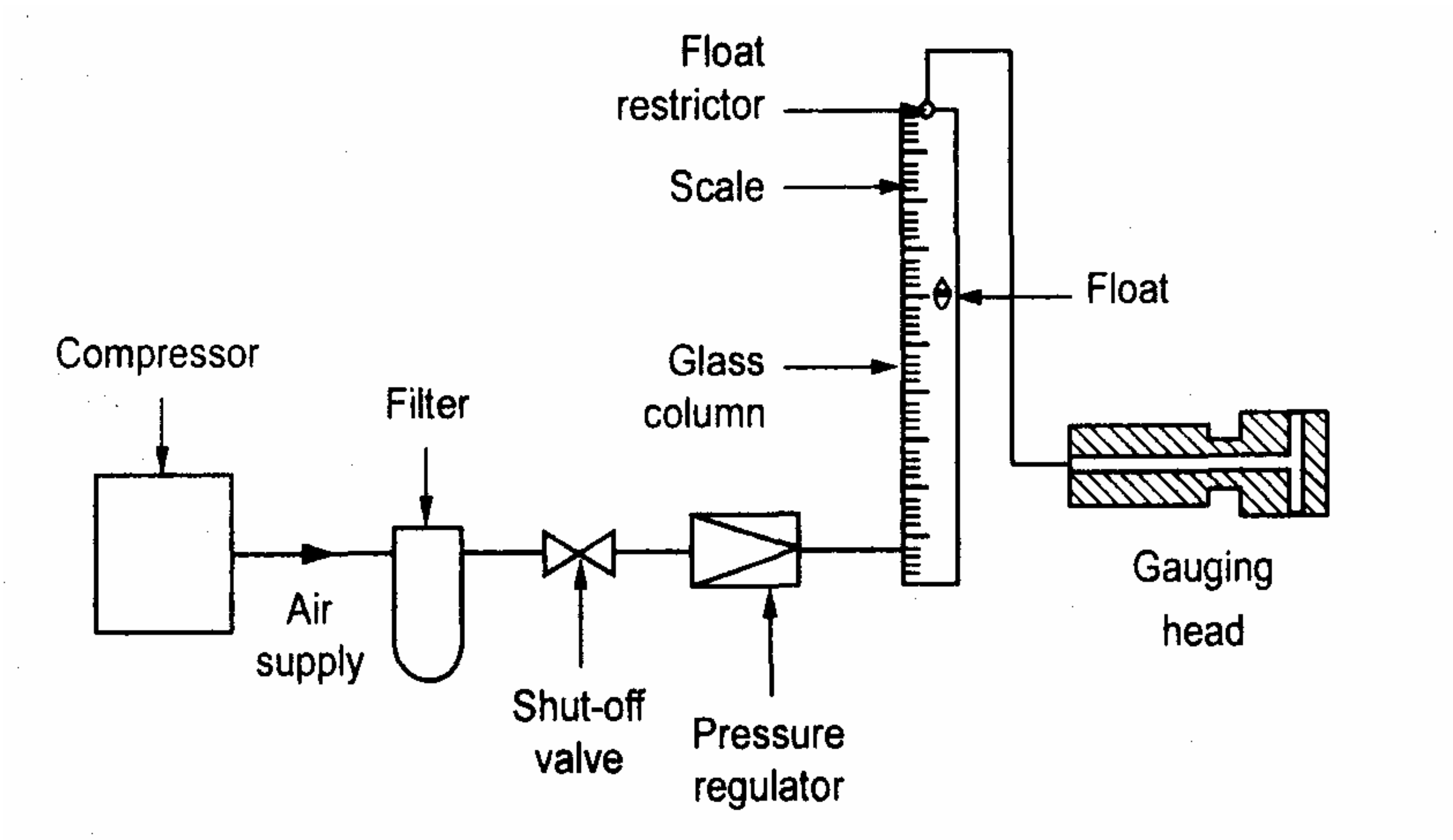
$$= \frac{a}{c} \times \frac{2R}{b}$$

$$= \frac{a}{c} \times \frac{X}{Y} \qquad \left(\therefore \frac{X}{Y} \simeq \frac{2R}{b}\right)$$

- **Advantages of Optical Comparators:**
- **1. High Accuracy:**
- **2. High Range:**
- **3. High Magnification:**
- **4. No Inertia:**
- **5. Parallex Eerror:**

- **Disadvantages of Optical Comparators:**
- **1. Costly:**
- **2. Size:**
- **3. Need Source of Light:**
- **4. Heating of Instrument:**
- **5. Need of Dark Room:**
- **6. Reading not Convenient:**

PNEUMATIC COMPARATORS:



- Pneumatic Comparators uses air as a means of magnification in metrology. This was originally developed by the Solex Company in France for the calibration of carburetors.
- The first application was the checking of the bores of motor-car cylinder blocks. Now it is almost used in production shop for this purpose.

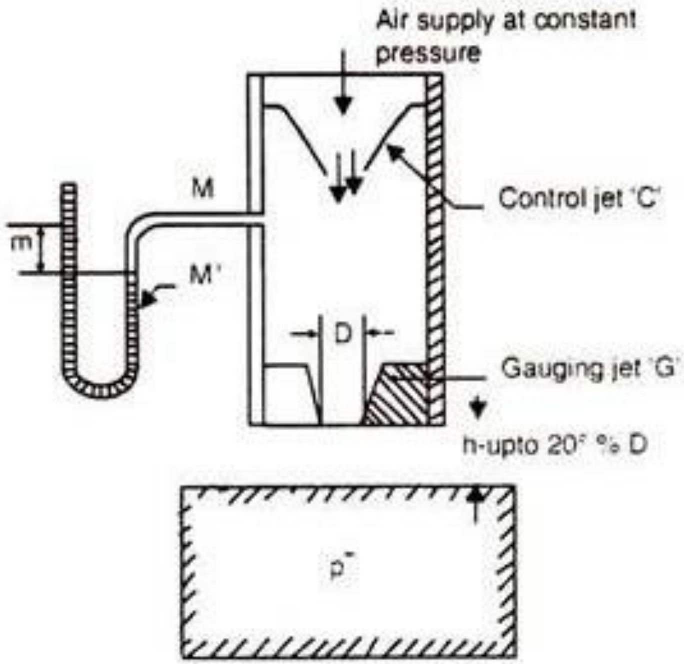


Fig. 1.16. Principle of pneumatic comparator.

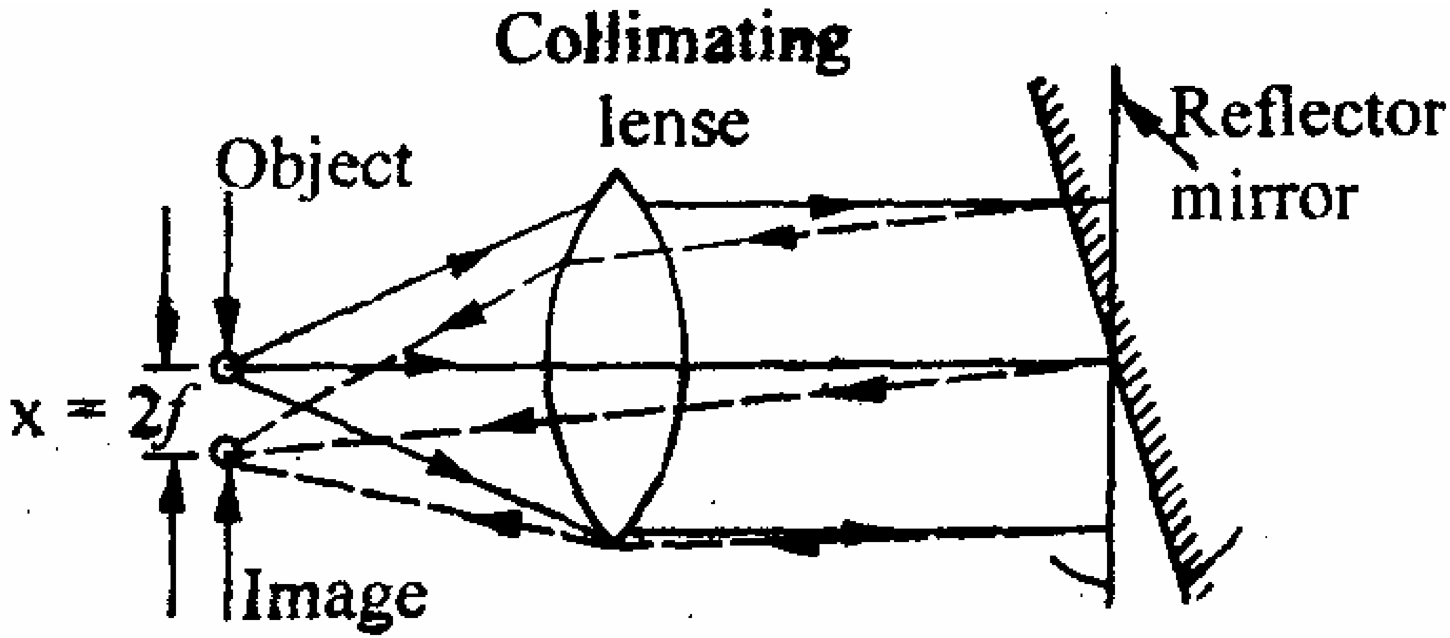
- The Pneumatic Comparator is based on Bernoulli's theory. The principle of working of a Pneumatic comparator is shown in figure 1.16. Air at a low (1,5kg./cm^2) but constant pressure, p_s, is supplied through a small jet 'c' into an intermediate chamber and then pass through a second orifice gauging jet 'G' to atmosphere.
- The component whose dimensions to be checked is placed below the gauging jet with some air gap as shown on Fig. 1.16. The amount of air escaping through gap between work piece 'p' and gauging jet 'G' will depend upon the gap h. The gap h will affect the intermediate pressure recorded by the manometer "M".

- If the gap ‘h’ is large, pressure recorded would be small. On the other hand if the gap ‘h’ is small, pressure would be higher.
- The gap ‘h’ initially set with the help of known standard usually slips gauges. The component whose dimensions to be checked is placed by removing the slip gauges.
- If the component has variation in size than the gap ‘h’ will increased or decreased. This will cause to change in intermediate pressure, and will change in the manometer reading. The manometer is calibrated directly to read linear scale.

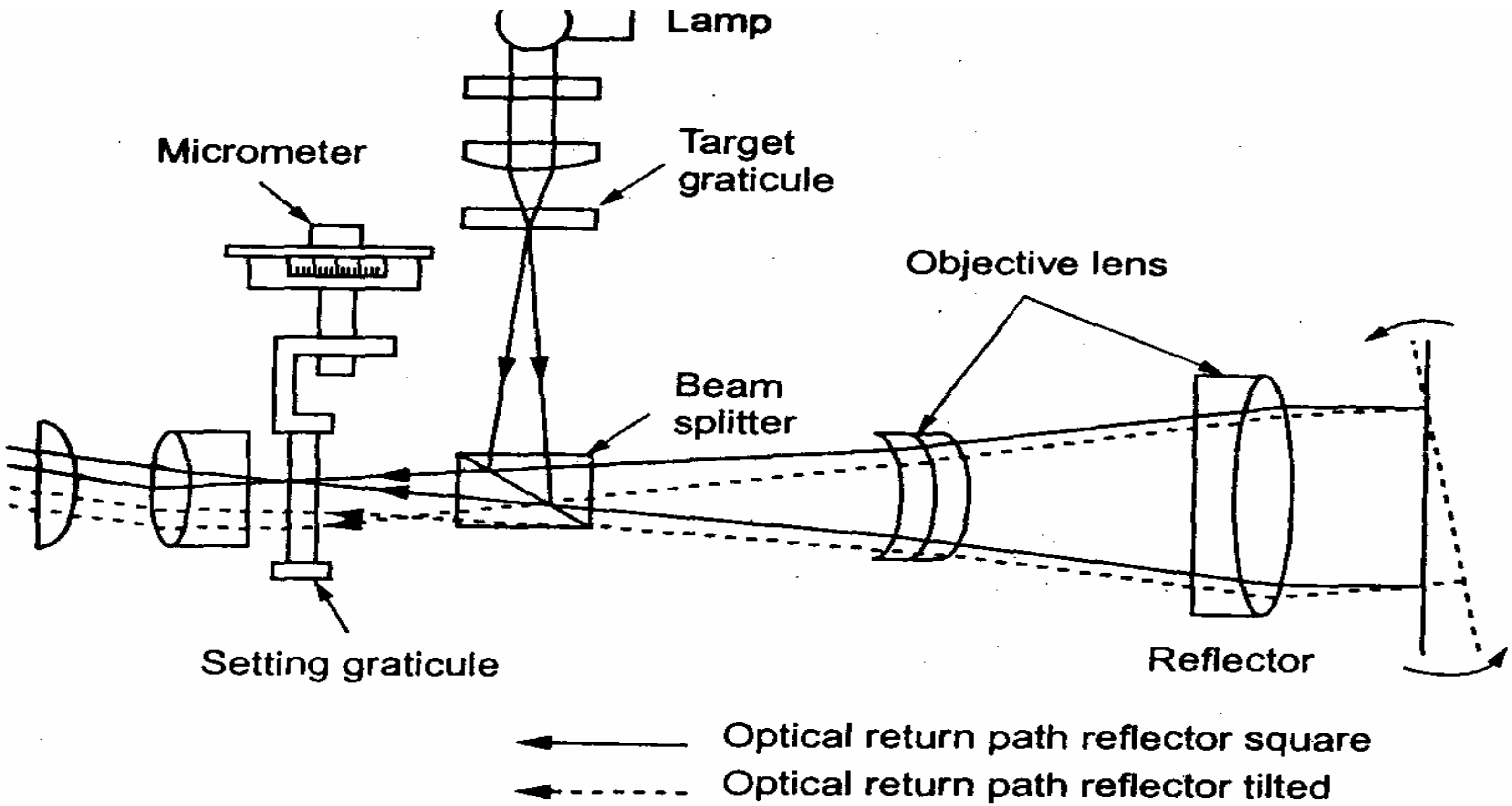
- **Advantages of Pneumatic Comparators:**
- **1. High Accuracy:**
- **2. Higher Magnification:**
- **3. Cleaning of Dust:**
- **4. Checking of Surface Positions:**
- **Disadvantages of Pneumatic Comparators:**
- **1. Need of Auxiliary Equipment’s:**
- **2. Non-Uniform Scale:**
- **3. Not Portable:**
- **4. Effect of Temp:**

Angular Measurement

AUTO- COLLIMATOR:

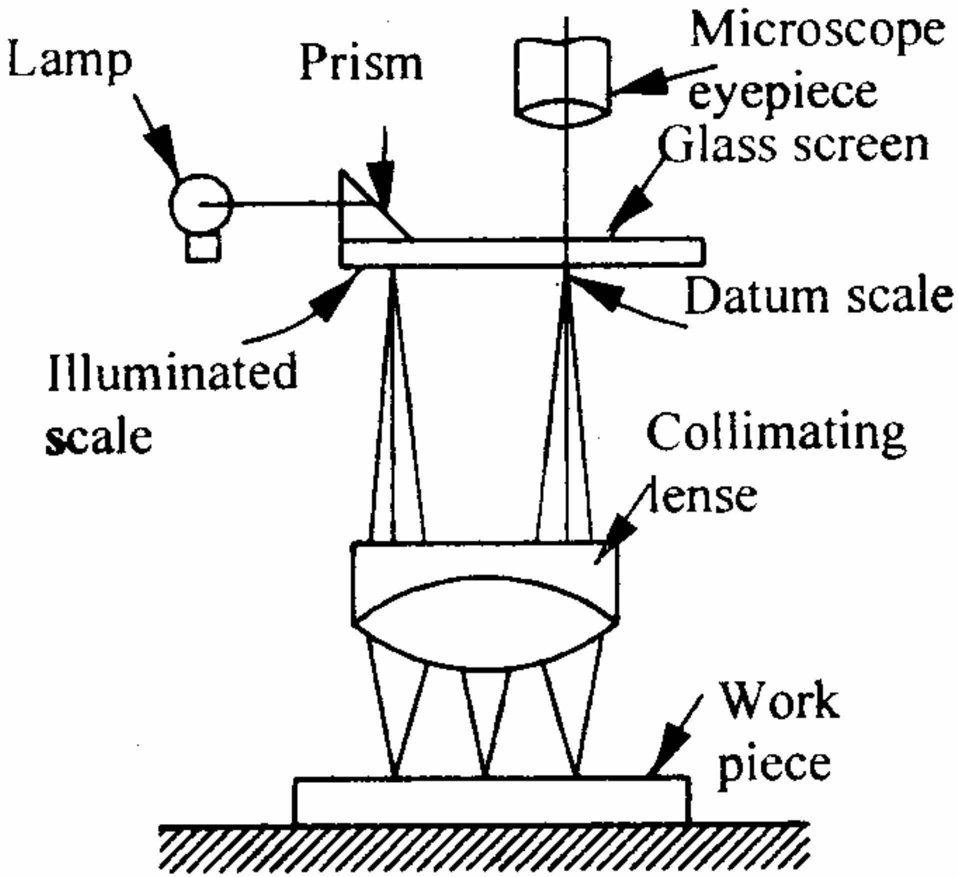


Working



Line diagram of an injected graticule auto-collimator

ANGLE DEKKOR

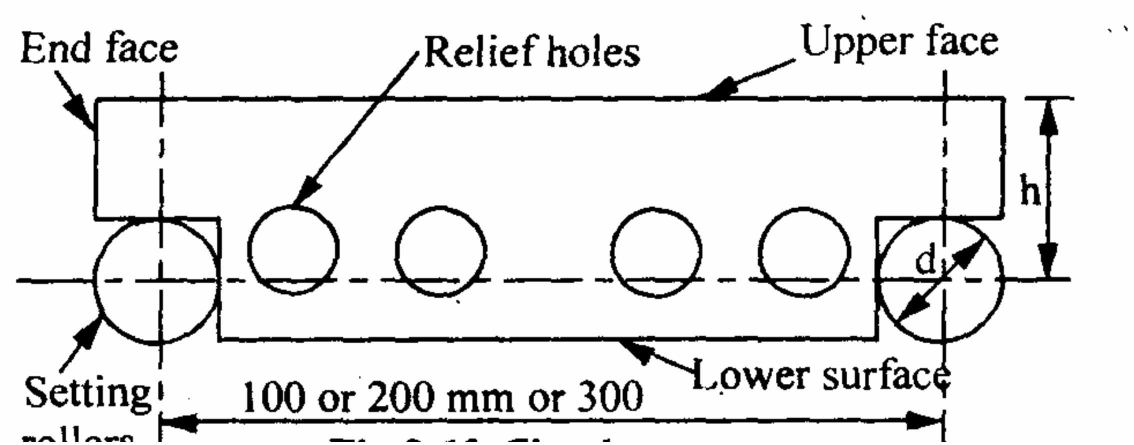


USES OF ANGLE DEKKOR:

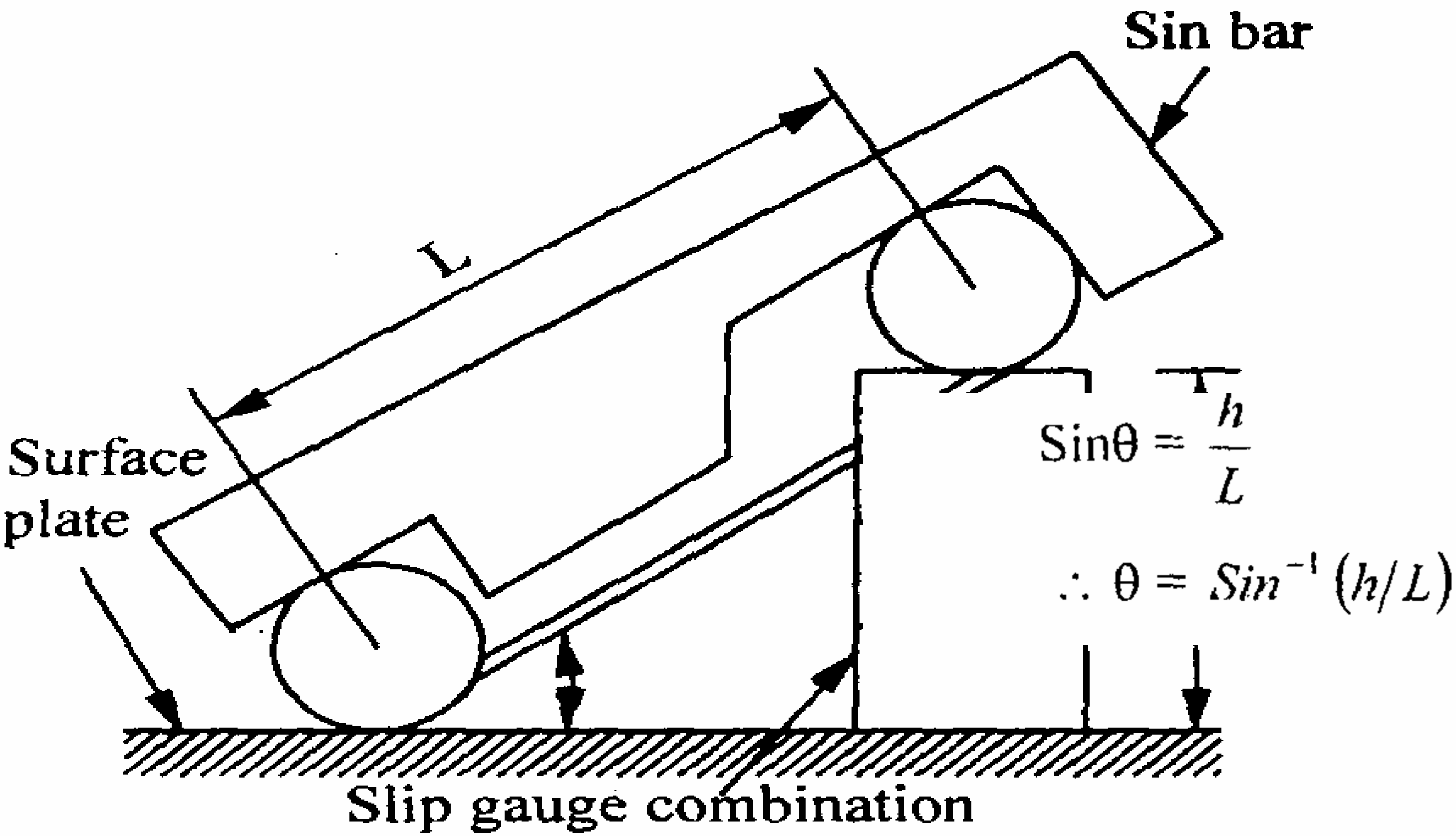
- (i) Measuring angle of a component:
- (ii) Checking the slope angle of a V-block:
- (iii) To measure the angle of cone or Taper gauge:

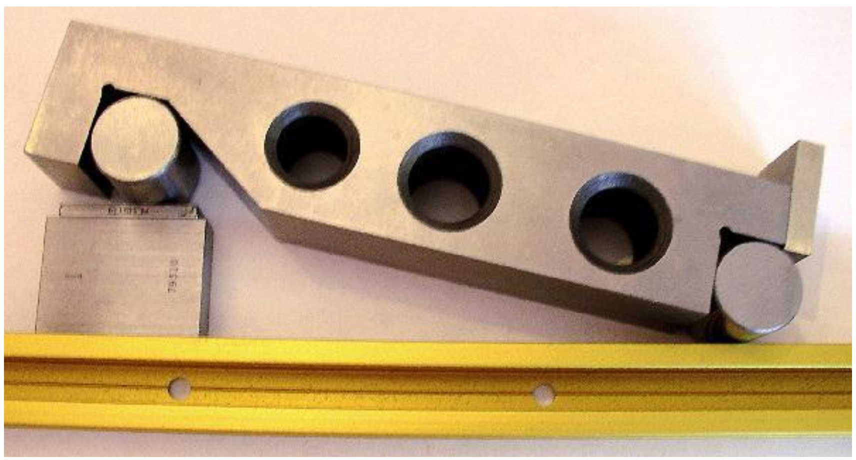
SINE BAR

- Sine bars are always used along with slip gauges as a device for the measurement of angles very precisely.



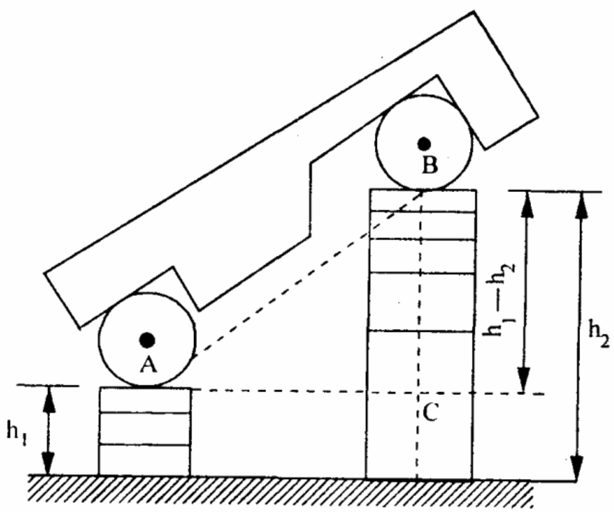
Working principle of sine bar:



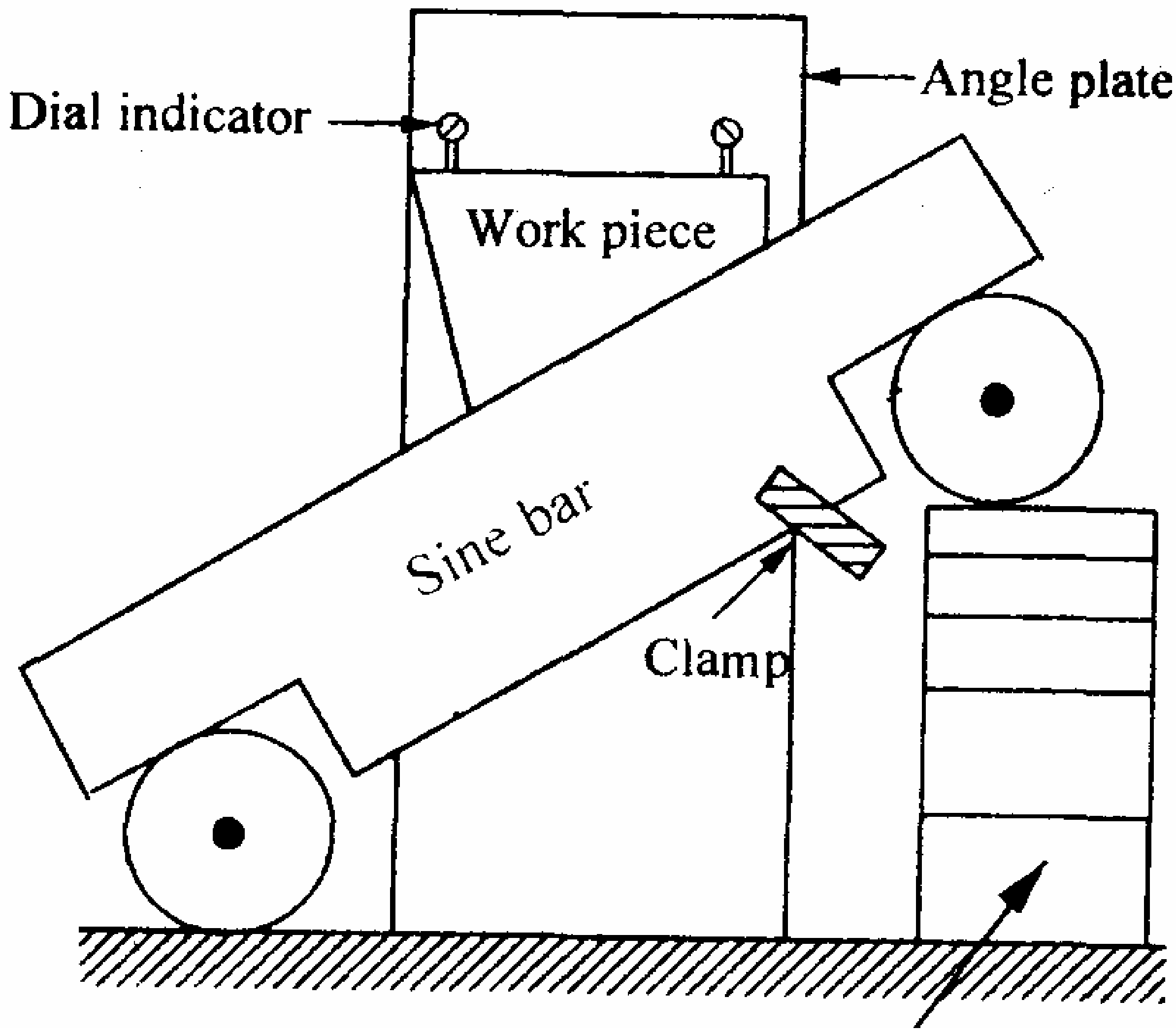


Accurate Method

For getting more accurate results, both the rollers can be placed slip gauges as shown in fig. 2.65.



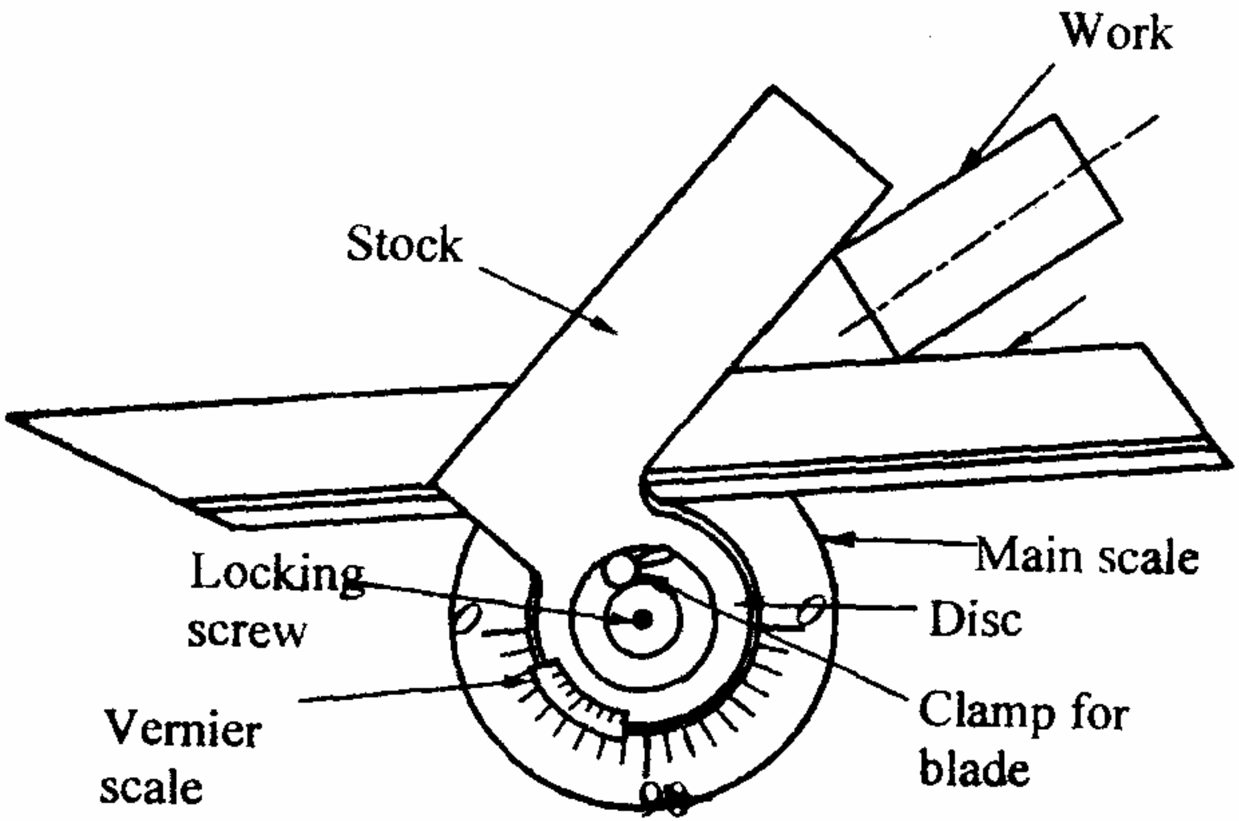
(ii) To check unknown angles:

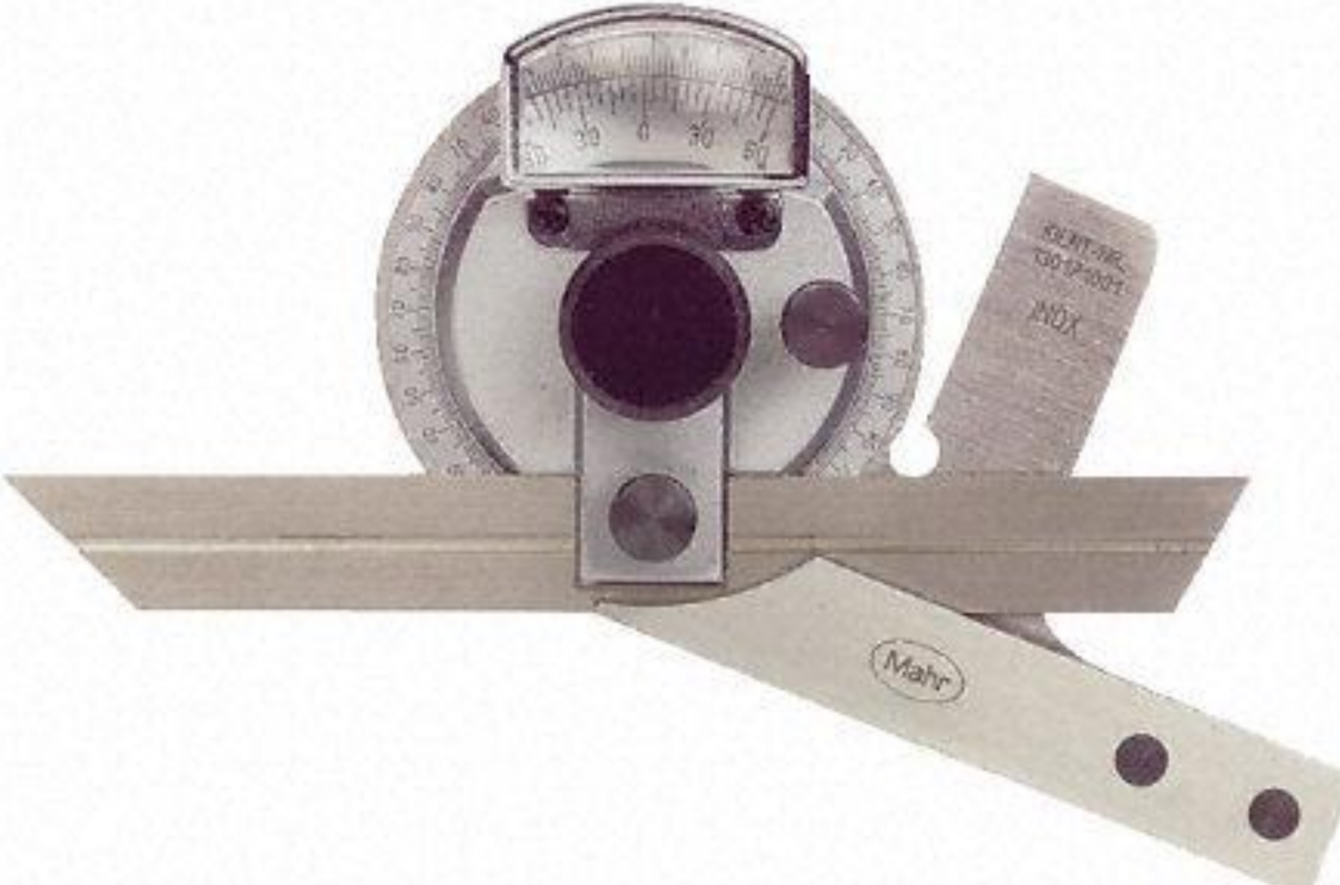


BEVEL PROTRACTORS

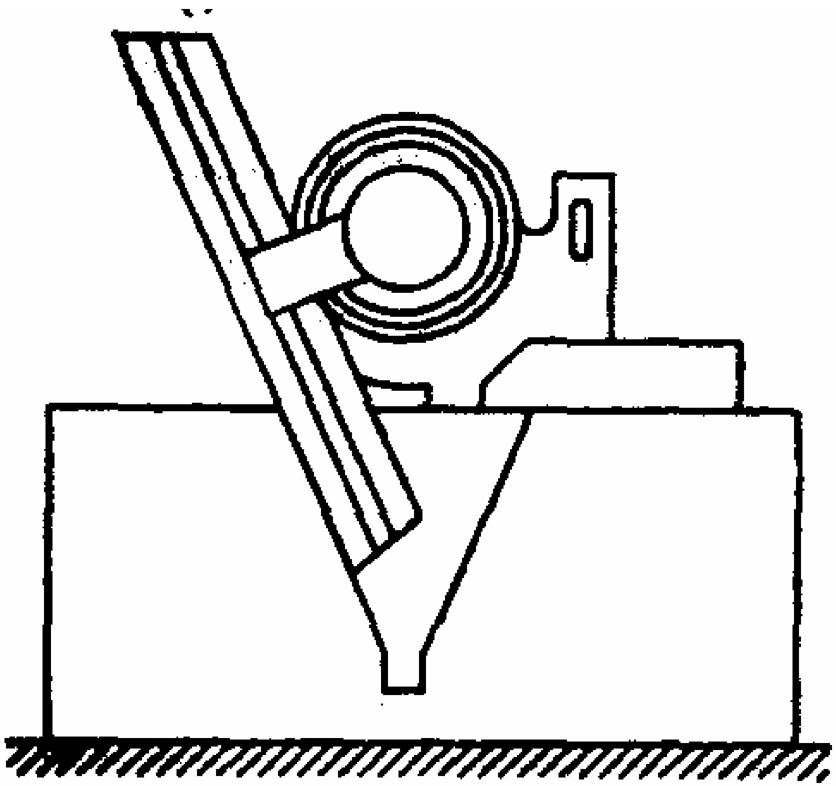
- Types of bevel protractors:
- The different types of bevel protractors used are:
  - 1) Vernier bevel protractor
  - 2) Universal protractor
  - 3) Optical protractor

Working principle:

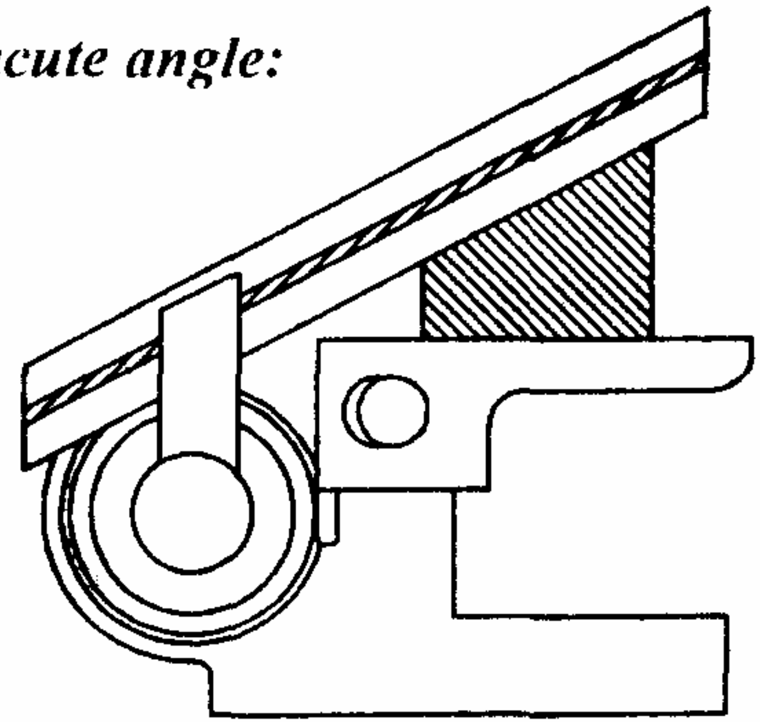



Mahr
INOX

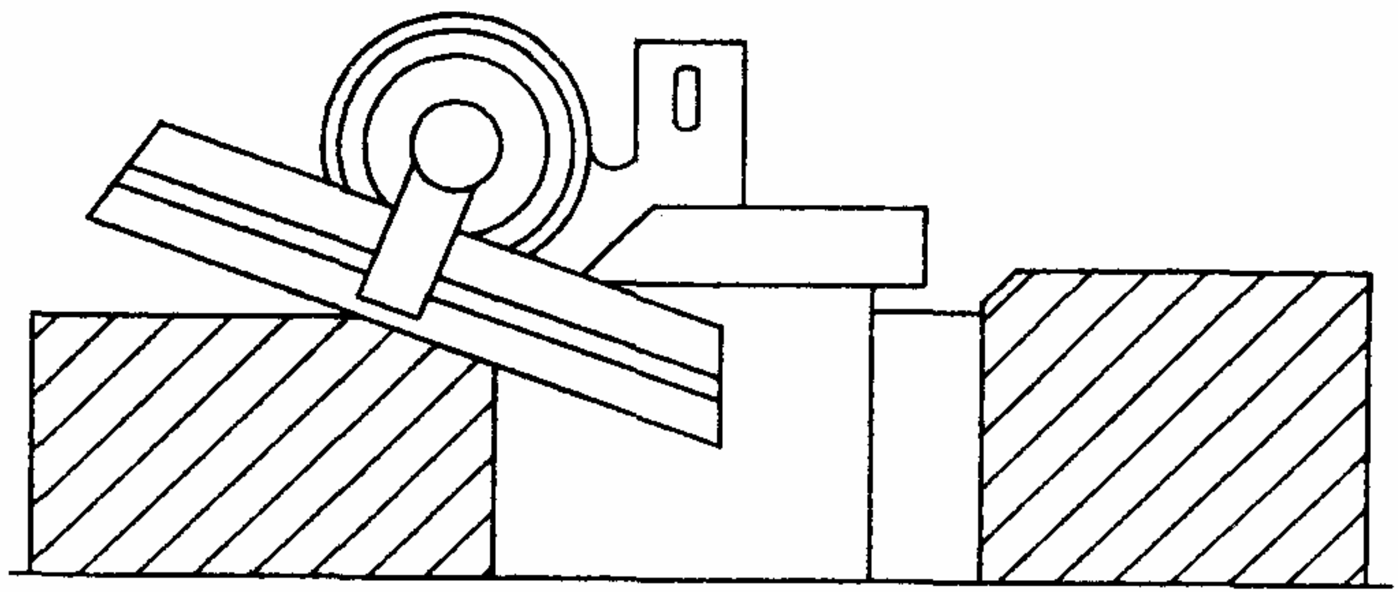
For checking a ‘V’ block:



2. For measuring acute angle:



3. For checking in inside beveled face of a ground surface.



Overview

- Linear measuring instruments: Vernier, micrometer and interval measurement- Slip gauges and classification. Interferometer, optical flat and limit gauges, Comparators: Mechanical, pneumatic and electrical types, applications.
- Angular measurements: -Sine bar, optical bevel protractor ,Taper measurements

UNIT III ADVANCES IN METROLOGY

Basic concept of lasers, advantages of lasers – laser interferometers – types – DC and AC lasers interferometer – Applications – Straightness – Alignment, Basic concept of CMM – Types of CMM – Constructional features – Probes – Accessories – Software – Applications – Basic concepts of Machine Vision System – Element –Applications.

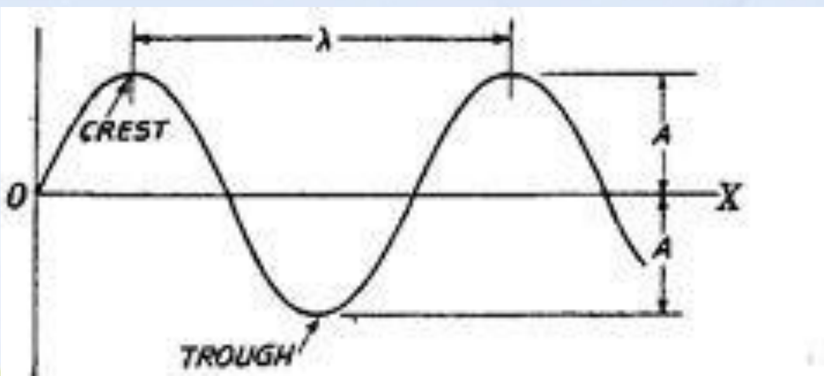
LIGHT

- Light makes the world seem bright and colorful to our eyes.

- Light is a type of electromagnetic radiation that carries energy from a **SOURCE (something that** makes light) at the very high speed of 186,000 miles per second (300,000 kps), or 670 million mph.

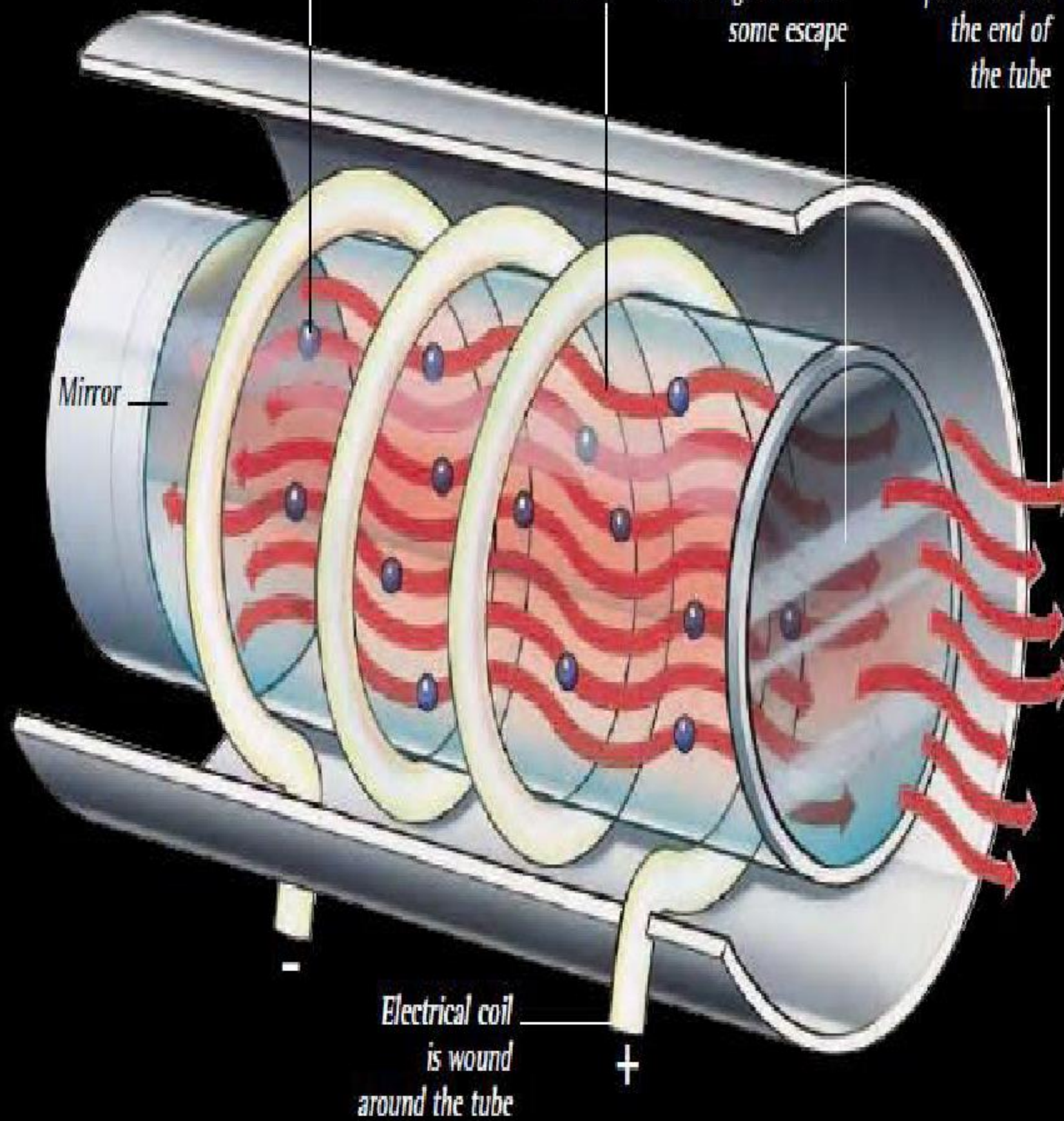
- Light rays travel from their source in straight lines. Although they can pass through some objects, they bounce off others or pass around them to make **SHADOWS.**

▲ WAVES AND PARTICLES
Sometimes light seems to behave as though it carries energy in waves. Other times it seems to carry energy in particles or packets, called photons, fired off in quick succession from the source. Scientists argued for many years over whether light was really a wave or a particle. Now they agree that light can behave as either a wave or a particle, depending on the situation.



LASERS

Some beams of light are powerful enough to cut through metal. Others are precise enough to use for delicate surgery on people's bodies. These remarkable forms of light are made by lasers. Laser stands for Light Amplification by Stimulated Emission of Radiation. A laser is a device that concentrates light rays so they all travel exactly in step. Laser rays are much more powerful and precise than other light rays.



PRECISION INSTRUMENTS BASED ON LASER

- Laser stands for "**Light Amplification by Stimulated Emission of Radiation**". Laser instruments are devices to produce powerful, **monochromatic** collimated beam of light in which the waves are coherent
- Properties of laser
  - **Monochromatic**
  - **Collimated beam**
  - **Coherent waves**
  - **Powerful**
- A typical helium-neon laser source produces a **1 to 2 mm** diameter beam of pure red light having power of **1MW.** So, this type of a beam is focused at a point. It means, beam has very high intensity. The laser is used extensively for interferometer. Upto a great distance beam has no divergence but then it begins to expand at a rate of about **1mm/m.**
- This is used for very accurate measurements in the order of **0.1 µm in 100m**.

PRECISION INSTRUMENTS BASED ON LASER

- Laser are extensively used for interferometry
- Metrology laser are low power instrument that emit visible pr infrared light.
- Light at a wave length of 0.6μ m is produced by He-Ne lasers.
- Laser are used for dimensions measurements and surface inspection.

VARIOUS LIGHT SOURCE

- Mercury
- Mercury 198
- Cadmium
- Krypton
- Krypton 86
- Sodium
- Helium
- Neon
- Gas lasers

LASER TELEMETRIC SYSTEM

- In general , telemetry means measurement made from distance.
- To detect change in dimension of the moving components. As the output of the system is in digital form.
- Laser telemetric system is a non contact gauge that measures with a collimated laser beam. It measures at the rate of 150 scans per second.

CONTRUCTION

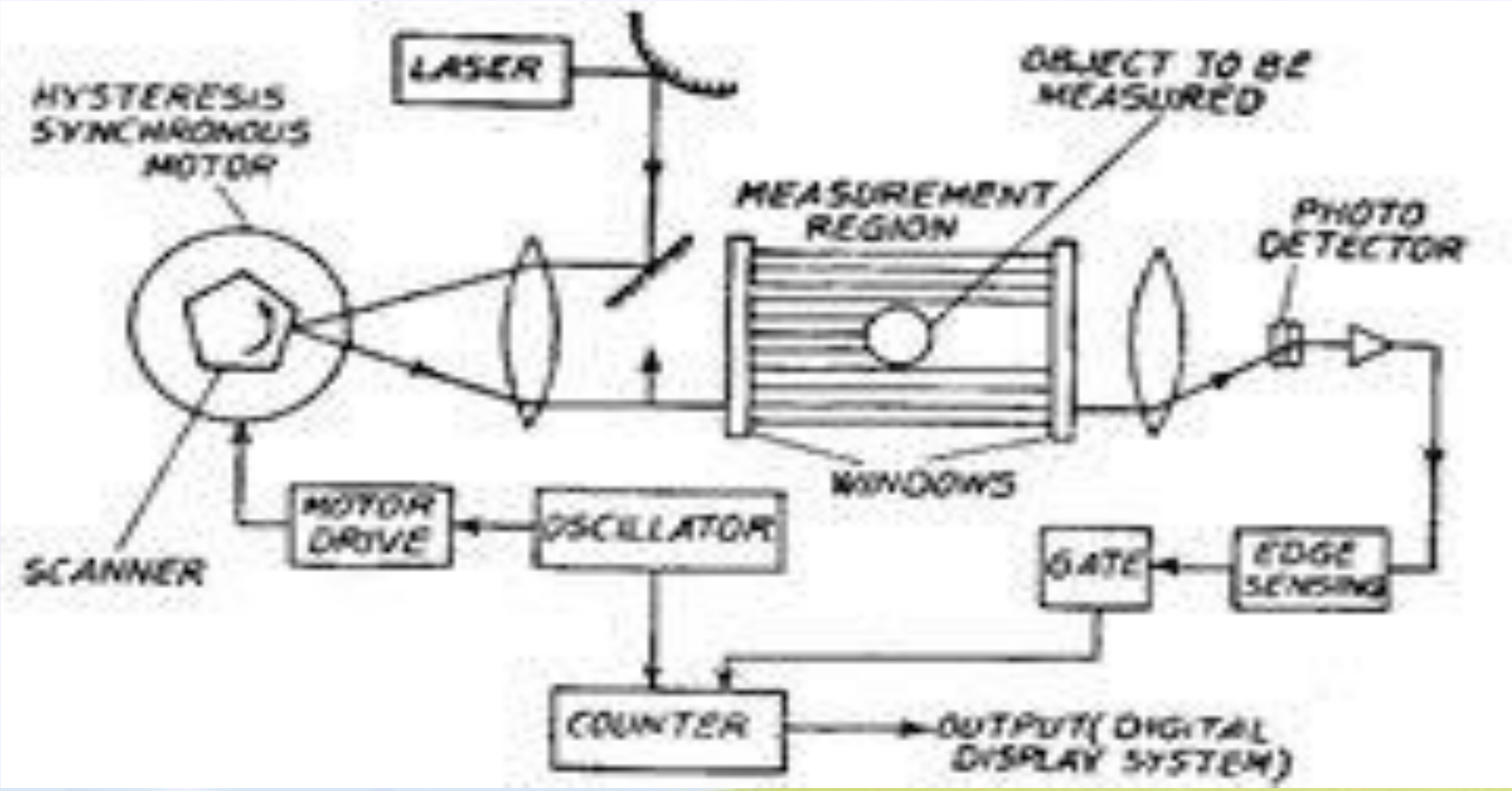
The laser telemetric system consists of mainly three components namely

1. Transmitter
2. Receiver
3. Processor electronics.

- The transmitter produces a collimated parallel scanning laser beam moving at a high constant linear speed. The beam appears as red line after scanning.
- The receiver collects the laser beam and photo electrically senses the laser light transmitted through the objects being measured. The processor receivers the signal and converts it into convenient from.

The transmitter has the following components.

1. Low power helium neon gas laser.
2. Synchronous motor.
3. Collimating lens.
4. Reflector prism
5. Synchronous pulse photo detector.
6. Replaceable window



WORKING

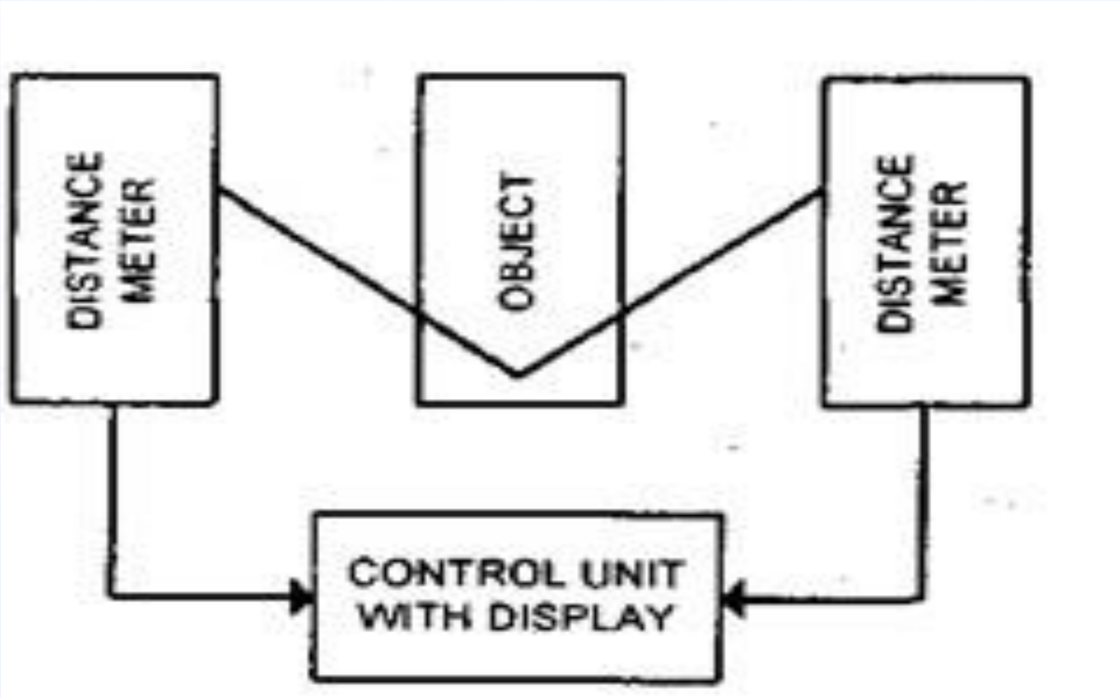
- The object to be measured is placed in the measurement region. High constant and linear speed laser beams from transmitter which is focused on the object to be measured. The receiver module collects and senses the laser light transmitted past the object to be measured.
- After sensing, the processor electronics take the received signals and convert them into a convenient from and then display the dimensions being gauged.

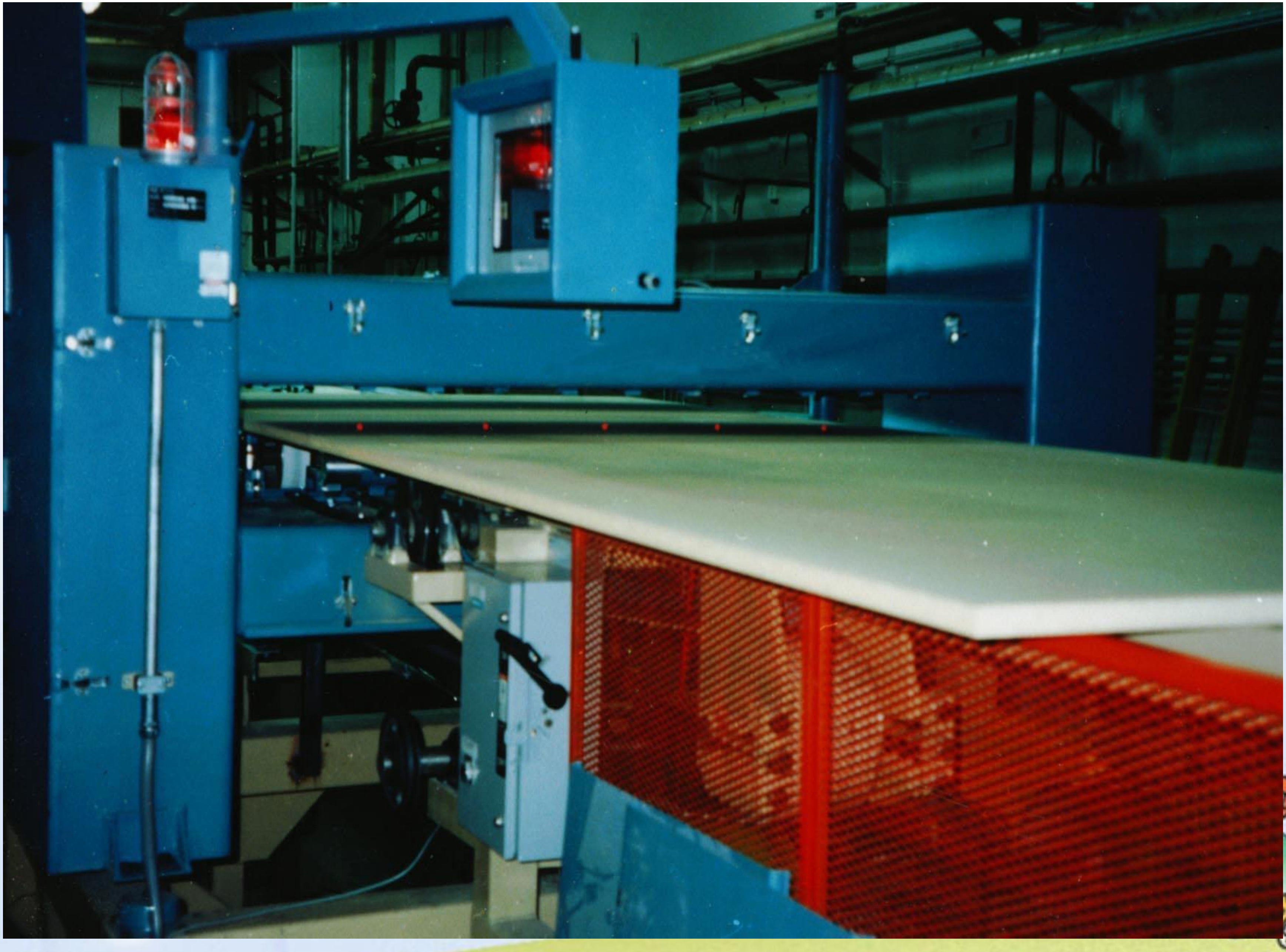
ADVANTAGES:

- It is possible to detect changes in dimensions when components are moving
- It is possible to detect changes in dimensions when product is in continuous processes.
- There is no need to wait for taking measurements when the product is in hot conditions
- It can be applied on production machines and controlled them with feedback loops
- It is possible to write programs for the microprocessor to take care of smoke, dust and other airborne interference around the work piece being measured.

LASER AND LED BASED DISTANCE MEASURING INSTRUMENTS

- It can measure distance from 1to 2m with accuracy of the order of 0.1 to 1% of the measuring range. The measuring system uses two distance meter placed at equal distance on either side of the object and a control unit to measure the thickness of an object.





WORKING

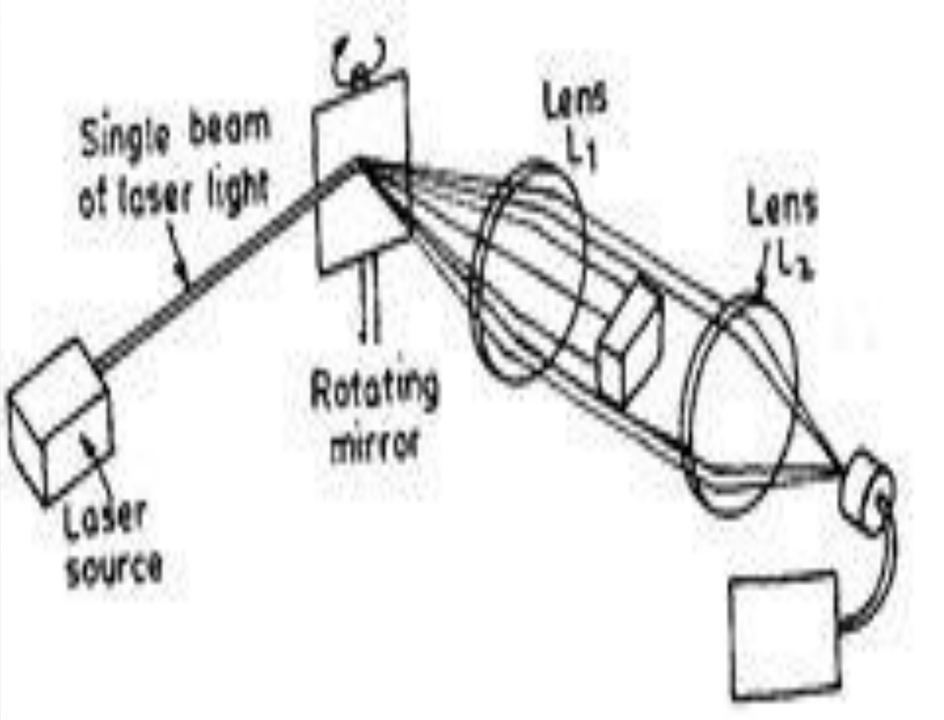
- When the light is emitted by laser or LED hits on object, it scatters and some of the scattered light is seen by a position sensitive detector or diode array.
- The angle at which the light enters the detector will change distance between the measuring head and object is changed. The change angle of deviation is measured and calibrated in terms of distance.

ADVANTAGE

- These types of instruments are very reliable because there is no moving part.
- Instrument response time is in milliseconds.
- The output is measured as 0-20mA.

SCANNING LASER GUAGE

- The scanning laser gauge is used for dimensional measurements. The figure shows a schematic diagram of a scanning laser gauge. It consists of transmitter, receiver and processor electronics.




FALCON
Vision
ENGINEERING
QUADRA-CHEK 300
Current Position
enter
finish
cancel
quit
Vision
ENGINEERING
Gain Control
On/off
Falcon Video Metrology Control Interface

WORKING

- A scanning laser light is made to pass through a liner scanner lens as a parallel beam. The object is placed in a parallel beam, casts a dependent shadow. The signals from the light entering the photocell are processed by a microprocessor to provide display of the dimension represented by the time difference between the shadow edges.

ADVANTAGES

- Accuracy of ±0.25 µm for 10-50mm diameter objects.
- It is used to measure objects of 0.05mm to 450mm diameter.

INTERFEROMETRY

INTRODUCTION

- The phenomenon of interaction of light is called interference.

- Under ordinary conditions, the wave nature of light is not apparent. But when the light waves interact with each other, the wave effect is visible and this is made use of for measuring purpose.

- A pattern of dark bands are produced when light is made to interfere. These bands correspond to accurate scale of division.

- The use of interferometric technique for measuring the interference, enables the size of slip gauges and end bars to be determined directly interms of the wavelength of the light source

MONOCHROMATIC LIGHT

- For length measurements by interferometry, monochromatic light source is used.
- A ray of light having a single frequency and wave length produces monochromatic light.

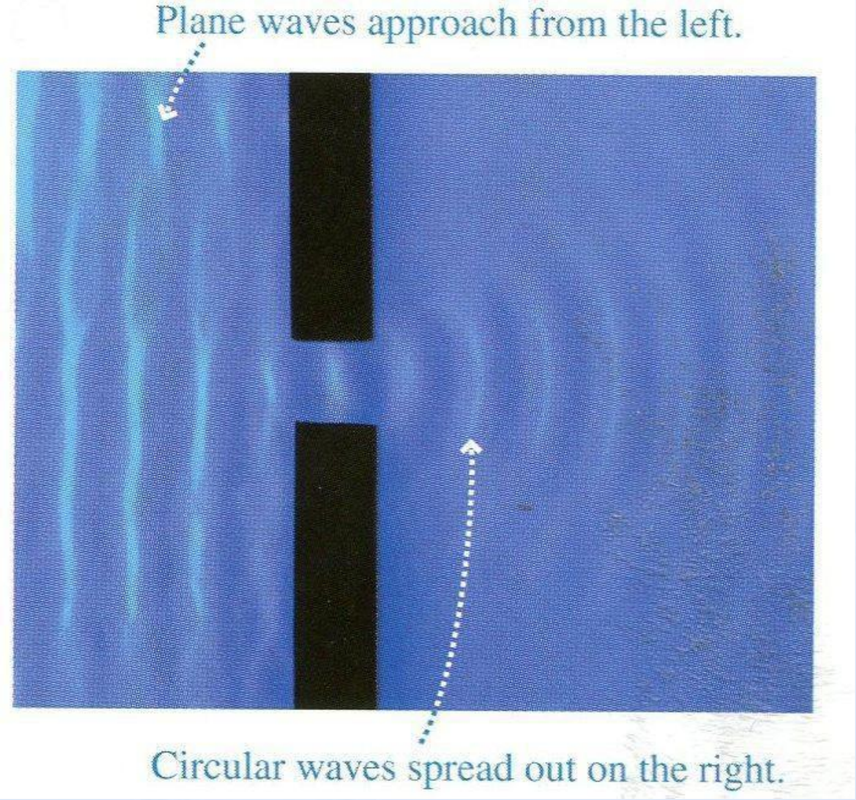
ADVANTAGES

- It is virtually independent by any ambient conditions.
- Its wavelength has precise value.
- It is reproducible.

Xiaoyu Ding

Physics Review

- Diffraction

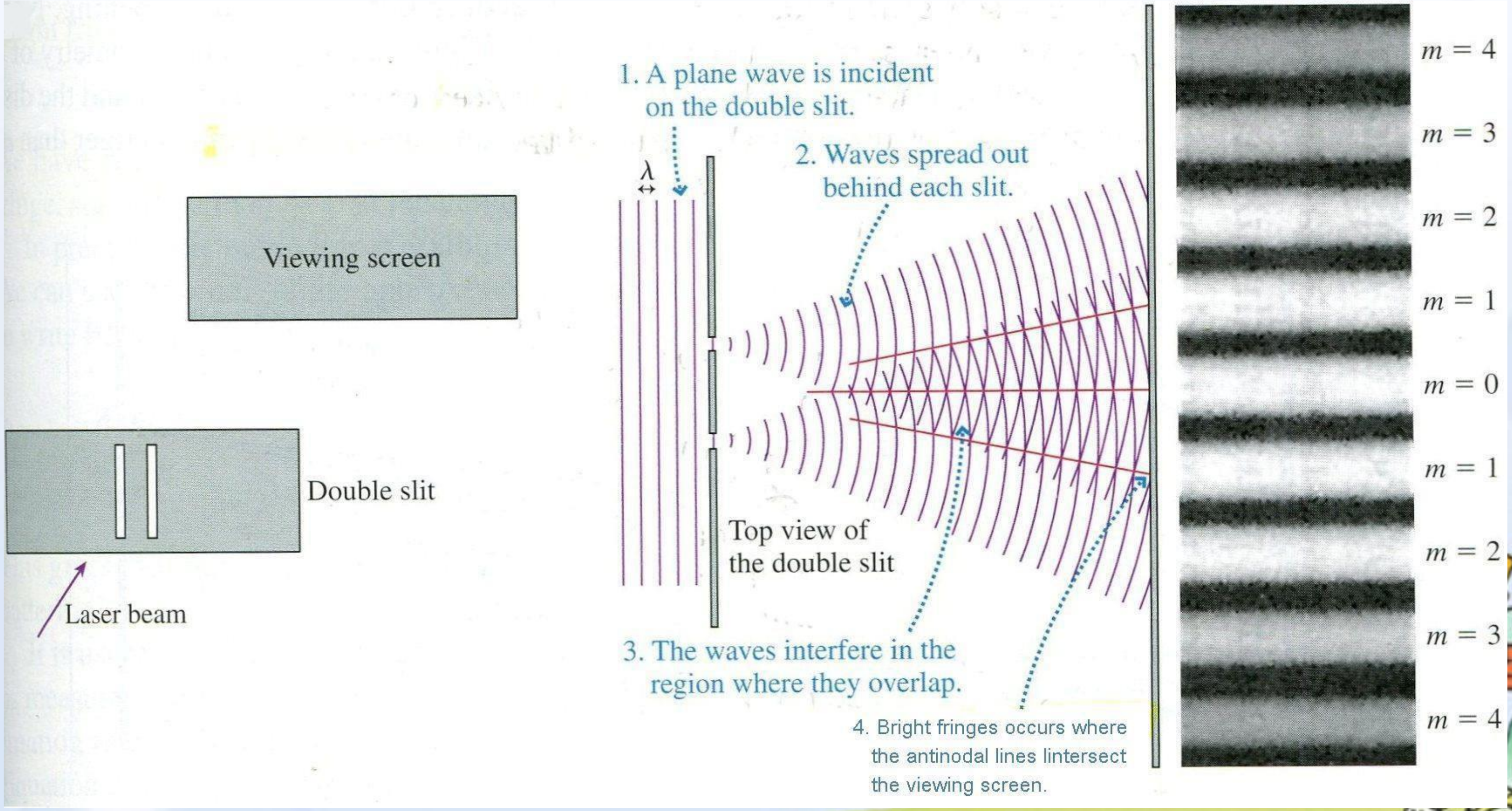


Diffraction of Water Waves

Diffraction is a sure sign that whatever is passing through the hole is a wave.

Physics Review

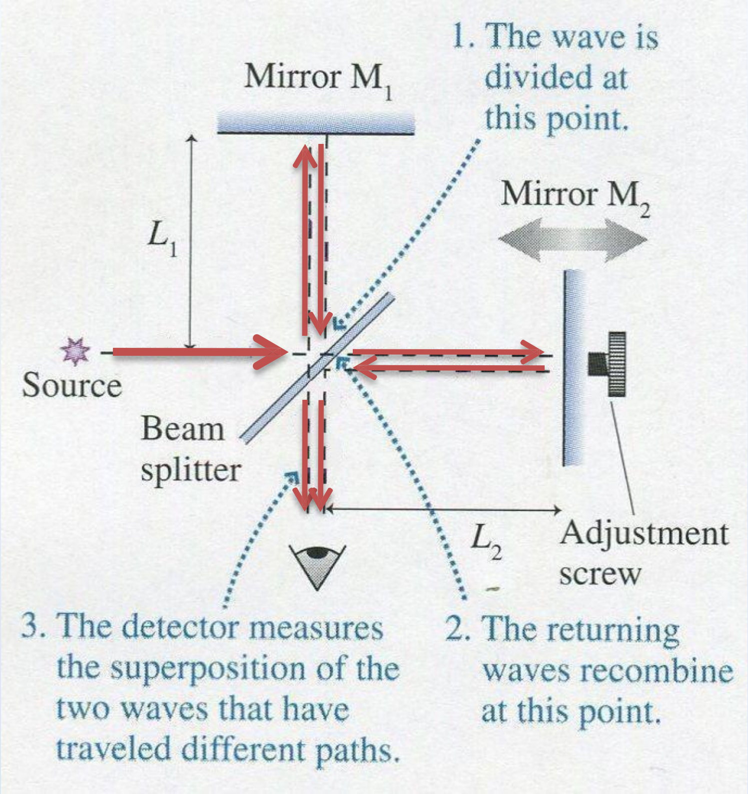
- A Double-Slit Interference Experiment



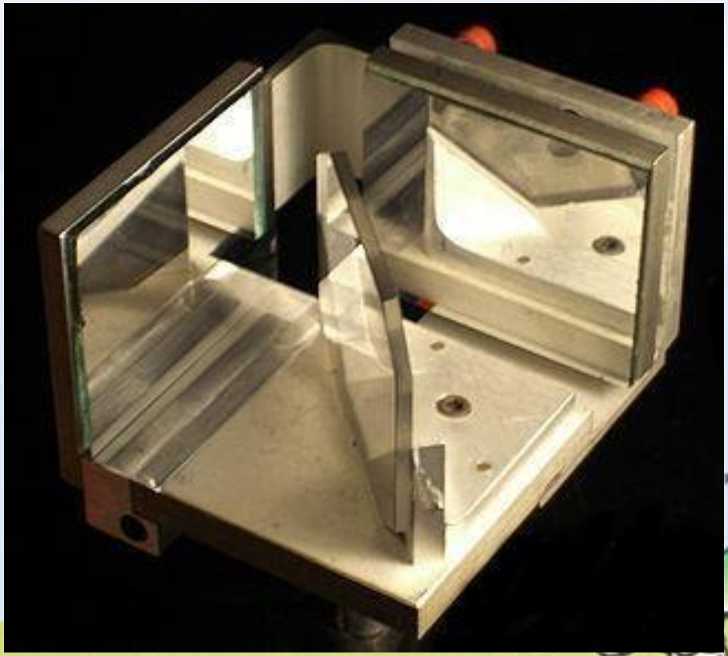
Xiaoyu Ding

Principle of Michelson Interferometer

- Michelson Interferometer

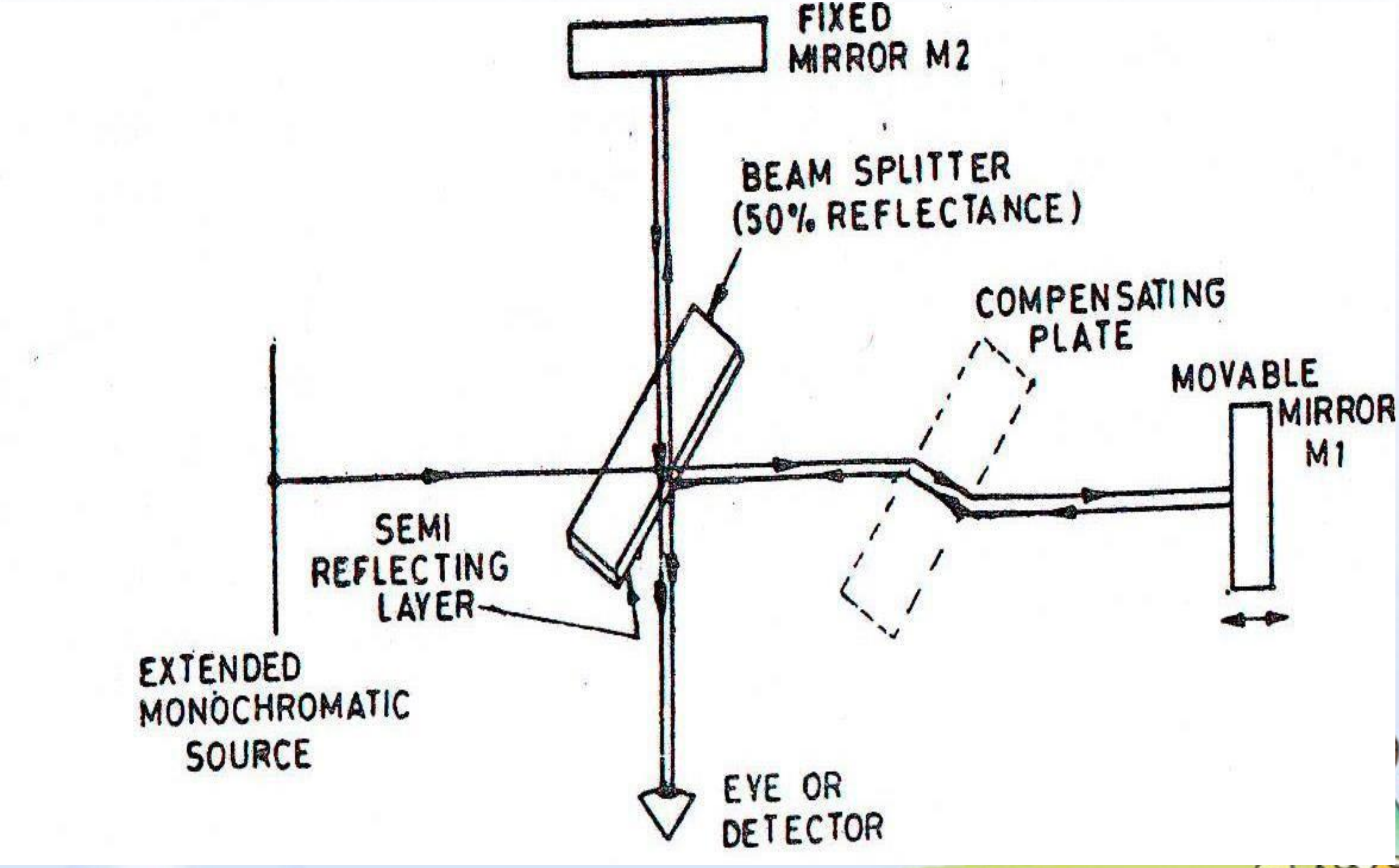


1) Separation
2) Recombination
3) Interference



A Michelson Interferometer for use on an optical table

MICHELSON INTERFEROMETER



MICHELSON INTERFEROMETER

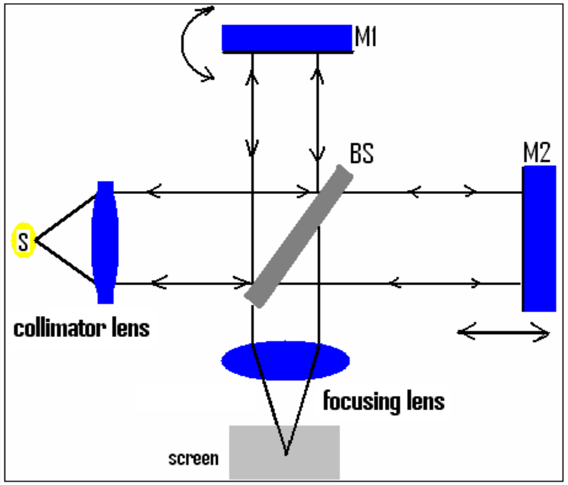
Construction and working:

- It is the oldest type of interferometer.
- The monochromatic light is made to fall on a beam divider. The beam divider splits the incoming light into two parts.
- It consists of two mirror M1 and M2 placed perpendicular to each other from the beam divider.
- The mirror M2 is fixed whereas M1 is movable. It is attached to the object whose dimension is to be measured.
- One part of the incoming light is transmitted through compensating plate P to the mirror M1.
- Other part is reflected through the beam divider to mirror M2.
- The rays are reflected back from the mirror and are reunited at the semi-reflecting surface where they are transmitted to the eye.

Twyman-Green interferometer

- **Configuration:**
  - A modified configuration of Michelson interferometer (rotatable mirror& a monochromatic point source)

- **Applications:** length measurements, optical testing e.g. lenses ,prisms, mirrors.

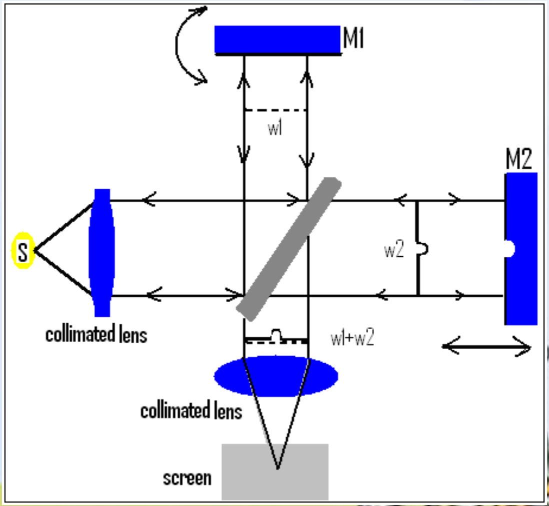


- **Work method:**

When the interferometer aligned properly, two images of the light source S from the two mirrors M_1&M_2 will coincide. The superposed waves are parallel and have a constant phase difference. On the serene a uniform illumination can be seen with a constant intensity depends on the path difference.

- **Mirror imperfections test:**

There will be an interference fringes due to the path difference between W_2 and the reference plan wave W_1

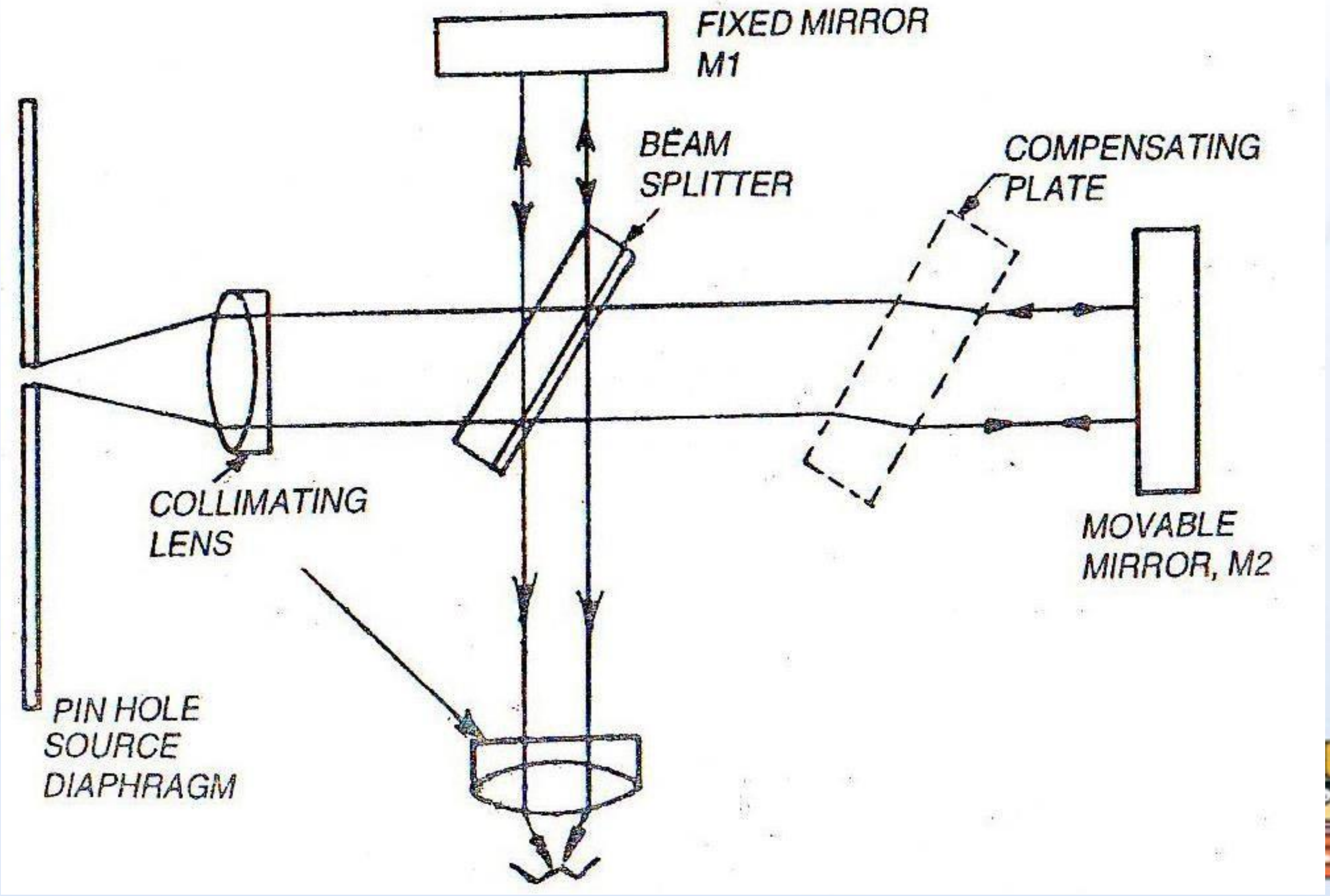


TWYMAN –GREEN SPECIALISATION OF MICHELSON INTERFEROMETER

Construction and working:

- In Michelson's interferometer, it is very difficult to interpret the fringe pattern.
- This was modified by Twyman -green. It utilises a pin –hole source diaphragm and collimating lenses.
- In this way , all rays are rendered parallel to the central rays and thus all rays describe the same path.
- It consists of two mirror M1 and M2 placed perpendicular to each other from the beam divider.
- The mirror M2 is fixed whereas M1 is movable. It is attached to the object whose dimension is to be measured.
- One part of the incoming light is transmitted through compensating plate P to the mirror M1.
- Other part is reflected through the beam divider to mirror M2.
- The rays are reflected back from the mirror and are reunited at the semi-reflecting surface where they are transmitted to the eye.
- Usually it is quite difficult to count such fringes by eye. However , photo detectors connected to high speed counters can do this job very accurately.

TWYMAN-GREEN SPECIALISATION OF MICHELSON INTERFEROMETER



Optical elements

The various optical elements are

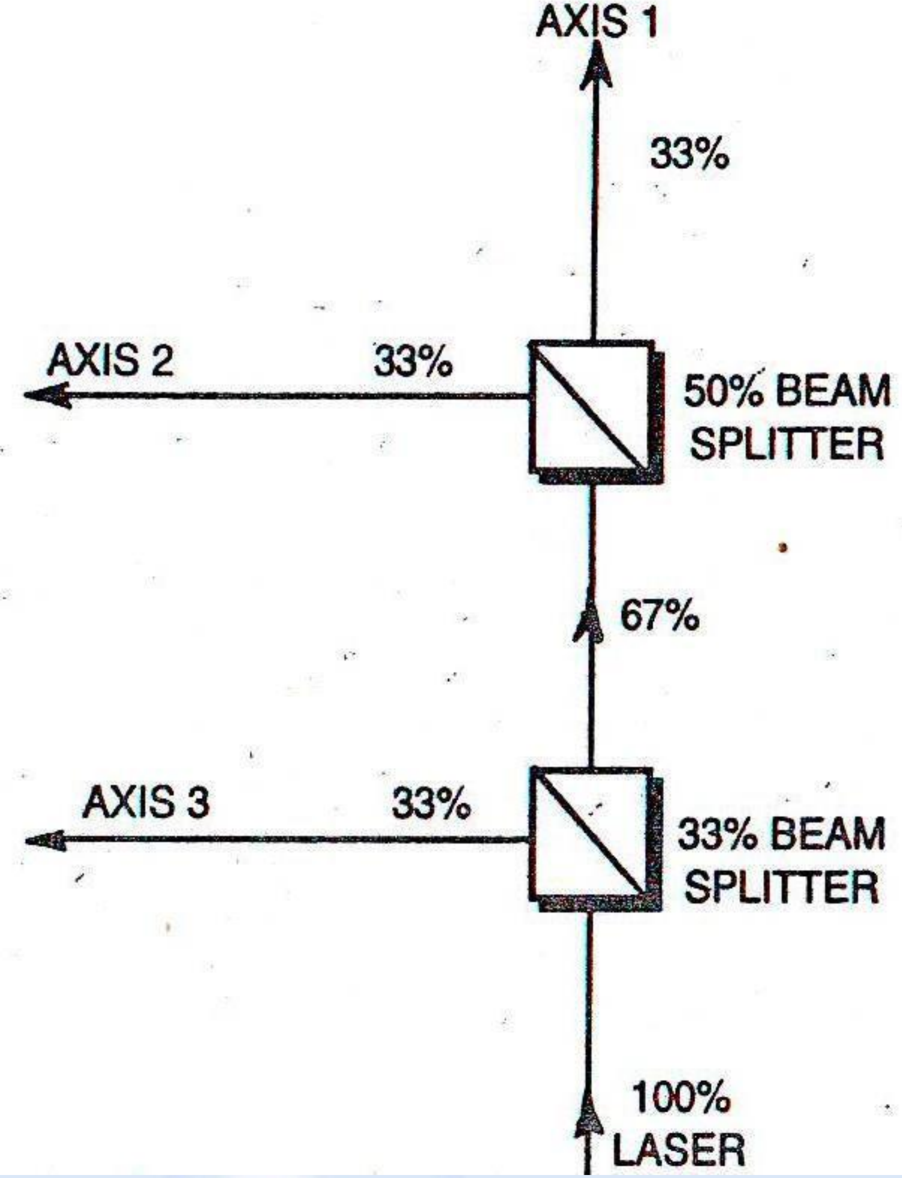
1. Beam splitters.
2. Beam benders
3. Retro reflectors

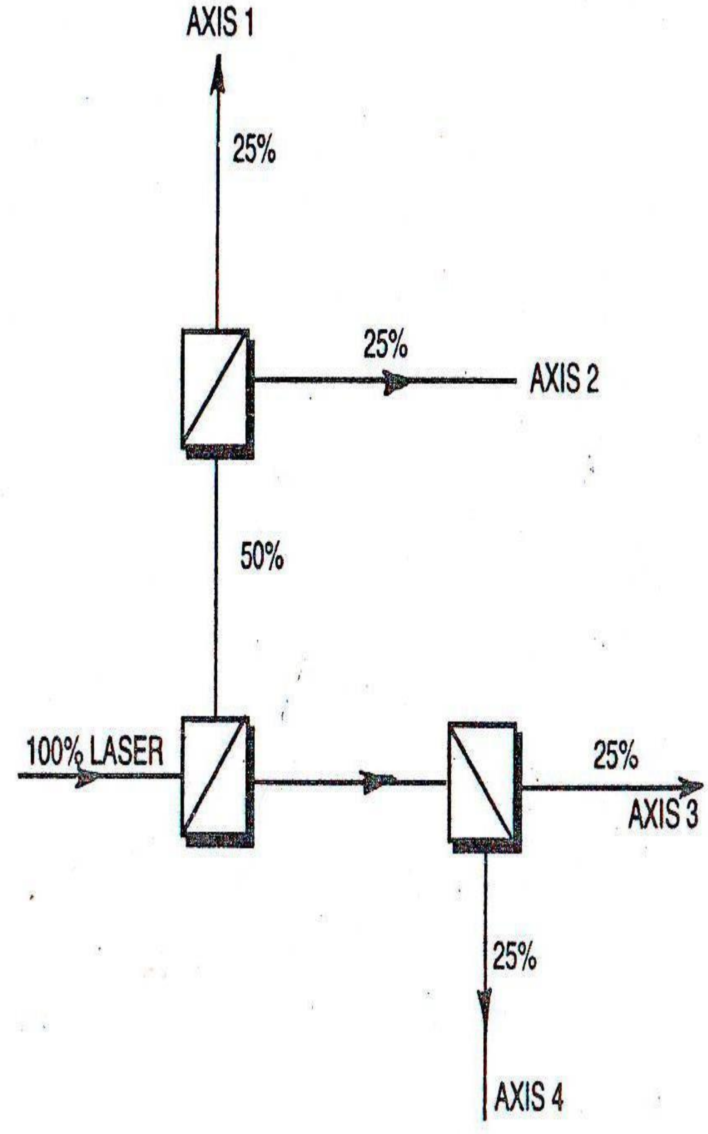
1. Beam splitters

- It is used to divide the laser beam in to separate beams along different axes. It is possible to adjust the splitters laser's output intensity by having a choice of beam splitter reflectivities.
- The below fig shows the use of beam splitters to divide the laser output equally along the different axis. For example, tacking 100% laser beam is splitted equally in three axes.

2. Beam benders

- It is used to deflect the light beam around corners on it path from the laser to the axis .the beam benders are just flat mirrors ,but having absolute flat and very high reflectivity .normally .the 90° beam deflection is avoided for not to disturb the polarizing vectors.


AXIS 1
33%
AXIS 2
33%
50% BEAM SPLITTER
67%
AXIS 3
33%
33% BEAM SPLITTER
100% LASER


AXIS 1
25%
25%
AXIS 2
50%
100% LASER
25%
AXIS 3
25%
AXIS 4

3. Retro reflectors

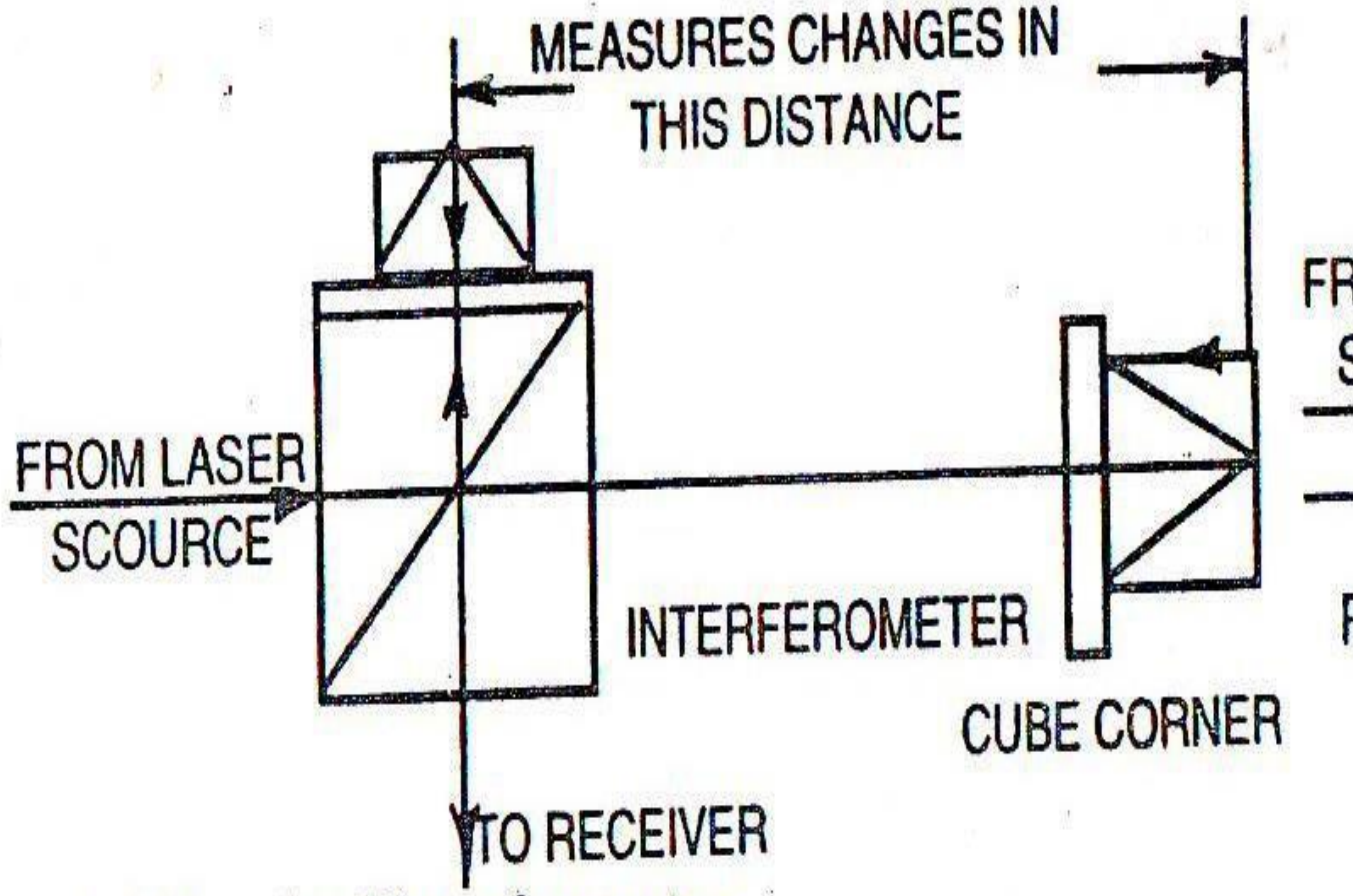
- They are plane mirrors, roof prism or cubic corners. The cube corners are 3 mutually perpendicular plane mirrors, and the reflected beam is always parallel to the incident beam in these devices.
- In case of AC laser interferometer measurements, two retro reflectors are used. When plane mirror is used as retro reflector in plane mirror interferometer, it must be flat with in 0.06micron per cm

3. LASER HEAD'S MEASUREMENT RECEIVER:

- It is used to detect the part of the returning beam as $f1$-$f2$ and a Doppler shifted frequency component Δf.

4. MEASUREMENT DISPLAY:

- The measurement display has a microcomputer to compute and display results. The signals from reference receiver and measurement receiver located in the laser head are counted in two separate pulse counter and subtract. Other input signals for correction are temperature co-efficient of expansions. Air velocity is also displayed.



(a) Standard Interferometer.

A.C LASER INTERFEROMETER

Introduction

Laser interferometer uses A.C laser as the light source and thus it enables the measurements to be made over longer distance. Laser represents a source of intensively monochromatic optical energy, which can be collimated into a directional beam. The laser beam wavelength is exact and pure for highly accurate measurements. The laser interferometers utilize the principles of both optical techniques and digital electronics.

Construction

The AC laser interferometer has the following components.

1. Two frequency Zeeman laser
2. Beam splitters.
3. Fixed internal cube corners.

4. External cube corners.
5. Photo detectors.
6. Amplifiers.
7. Pulse converter.

1. Two frequency Zeeman laser.

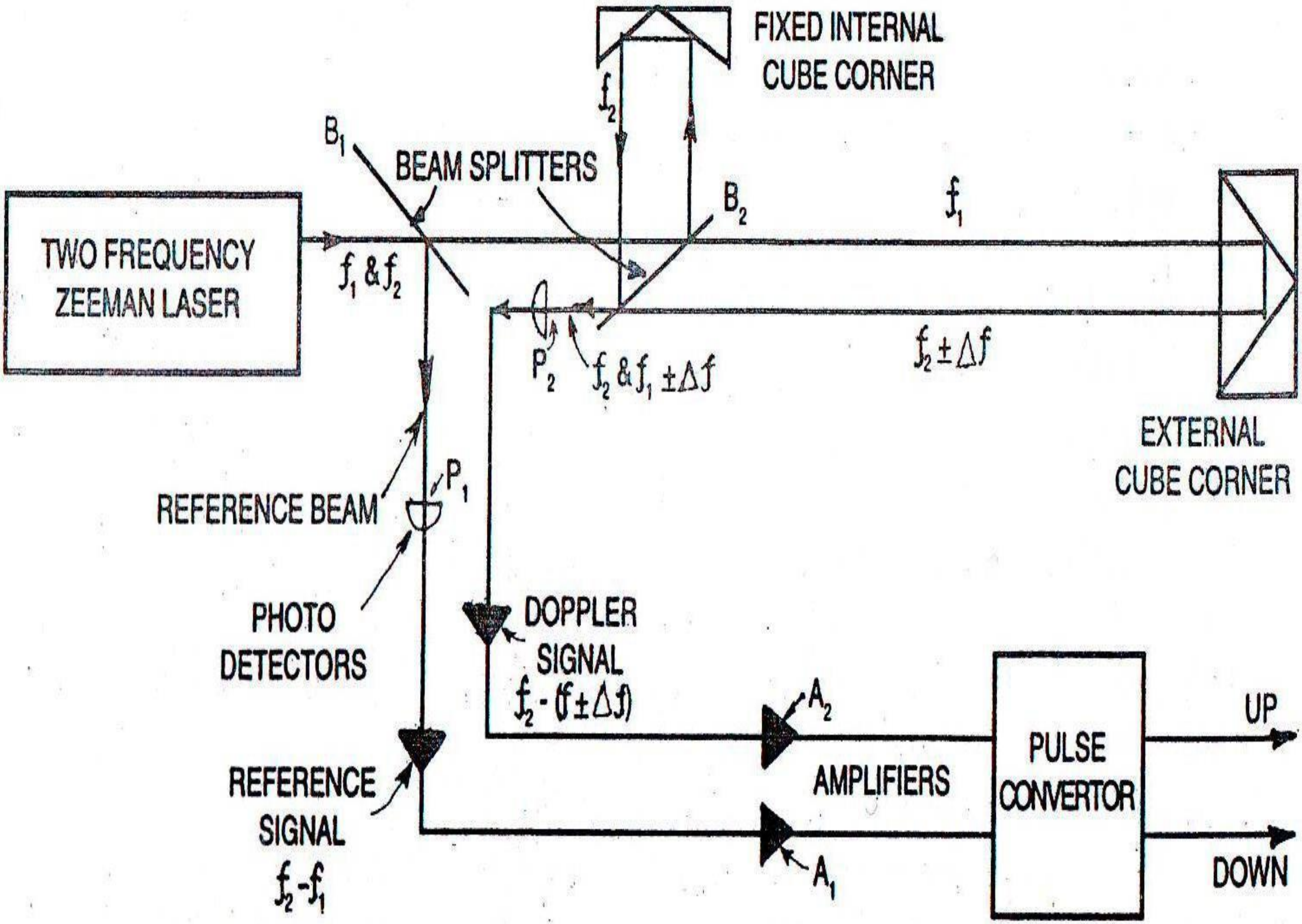
It is generally He-Ne type that generates stable coherent light beams of two frequencies, one is polarized vertically and the other one is polarized horizontally relative to the plane of the mounting.

2. Beam splitters

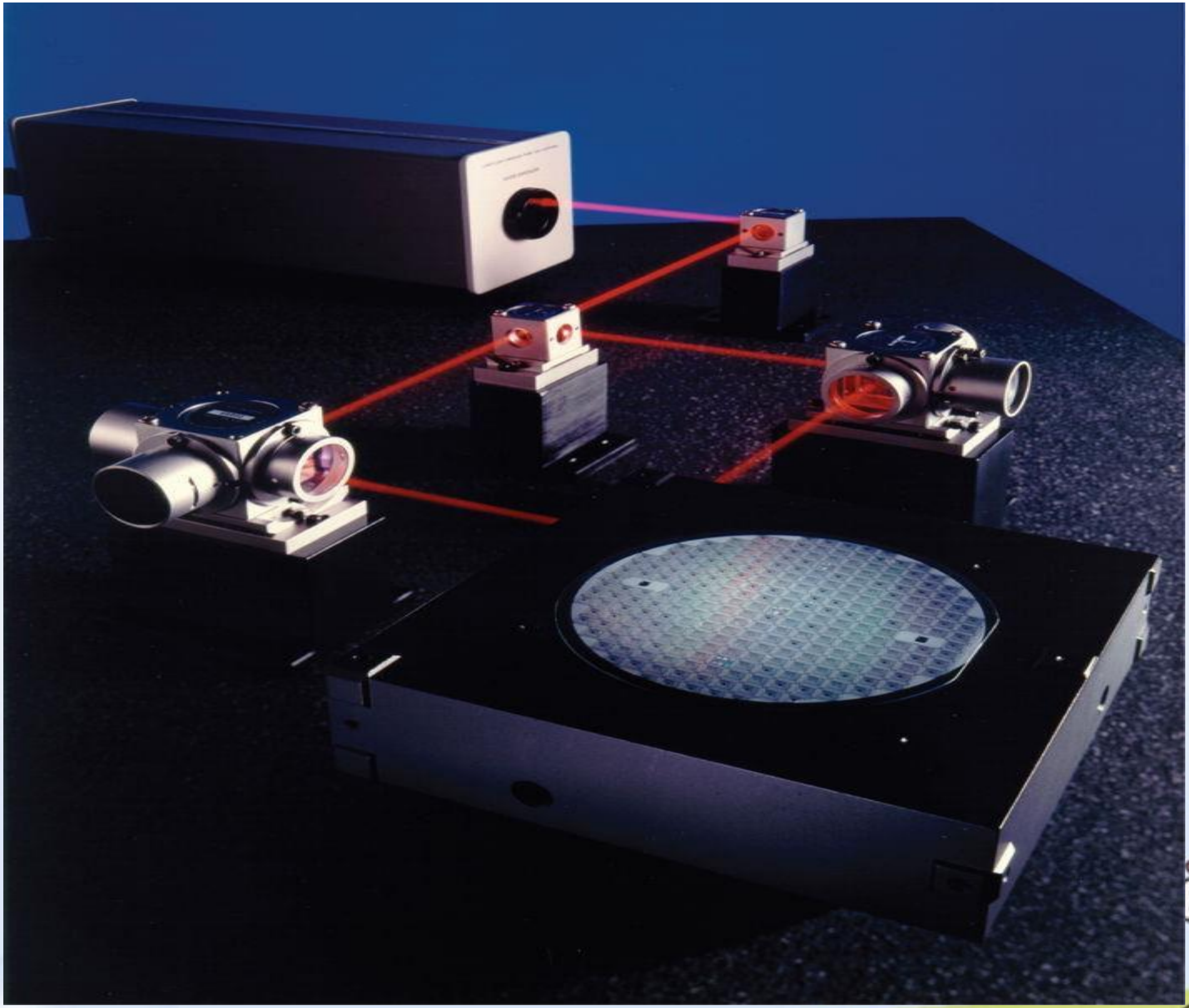
It divides the laser beam into separate beams along different axis. It is possible to adjust the splitted laser's output intensity by having a choice of beam splitter reflectivities.

3. Cube corners

The cube corners can be plane mirrors roof prisms. Each AC laser interferometers are required at least two retro frequencies. One is fixed external cube corner and another one is external cube corner. Both the cube corners are used to reflect the laser beam.



FIXED INTERNAL
CUBE CORNER
f_2
B_1
BEAM SPLITTERS
B_2
f_1
TWO FREQUENCY
ZEEMAN LASER
f_1 & f_2
P_2
f_2 & $f_1 \pm \Delta f$
$f_2 \pm \Delta f$
EXTERNAL
CUBE CORNER
REFERENCE BEAM
P_1
PHOTO
DETECTORS
DOPPLER
SIGNAL
$f_2 - (f \pm \Delta f)$
A_2
UP
PULSE
CONVERTOR
AMPLIFIERS
REFERENCE
SIGNAL
$f_2 - f_1$
A_1
DOWN




LZR2000

4. Photo detectors

Photo detectors receive the signal from the beam splitters and changers into electrical signal.

5. Amplifiers

There are two amplifiers used in AC laser interferometer. It is used to separate the frequency difference.

6. Pulse converter

The pulse converter is used to extracts change in frequency Δf.

Working

The two frequencies Zeeman laser generate light of two slightly different frequencies with opposite circular polarizations. The beams are splitted by the beam splitters B1. In this, one part travels towards B2 and from B2 to external cube corners, where the displacement is measured.

Beams splitter B2 optically separates the frequencies f1 which is sent to a fixed reflector and then rejoins f1 at the beam splitter B2 to produce alternate light and dark interference. Now, the external cube corner moves which it will produce a change in f1(i.e.,Δf1) in the returning beam frequency. So, the light beams move towards photo detectors p2 having frequencies f2(i.e.,f1 to Δti) and p2 will be changed into electrical signal.

The photo detector p1 receives signal from beam splitter B1 and changes the references beam f1 and f2 into electrical signal. The two amplifiers A1 and A2 separate frequency difference signals f2-f1 andf2-(f1+Δf). The pulse converter extracts Δf and displays in the form of pulses in analog or digital form in the output.

Basic Principles of Coordinate Measuring machines

Basic Principles of Coordinate Measuring machines

A coordinate measuring machine (CMM) is a device for measuring the physical geometrical characteristics of an object.

This machine may be manually controlled by an operator or it may be computer controlled.

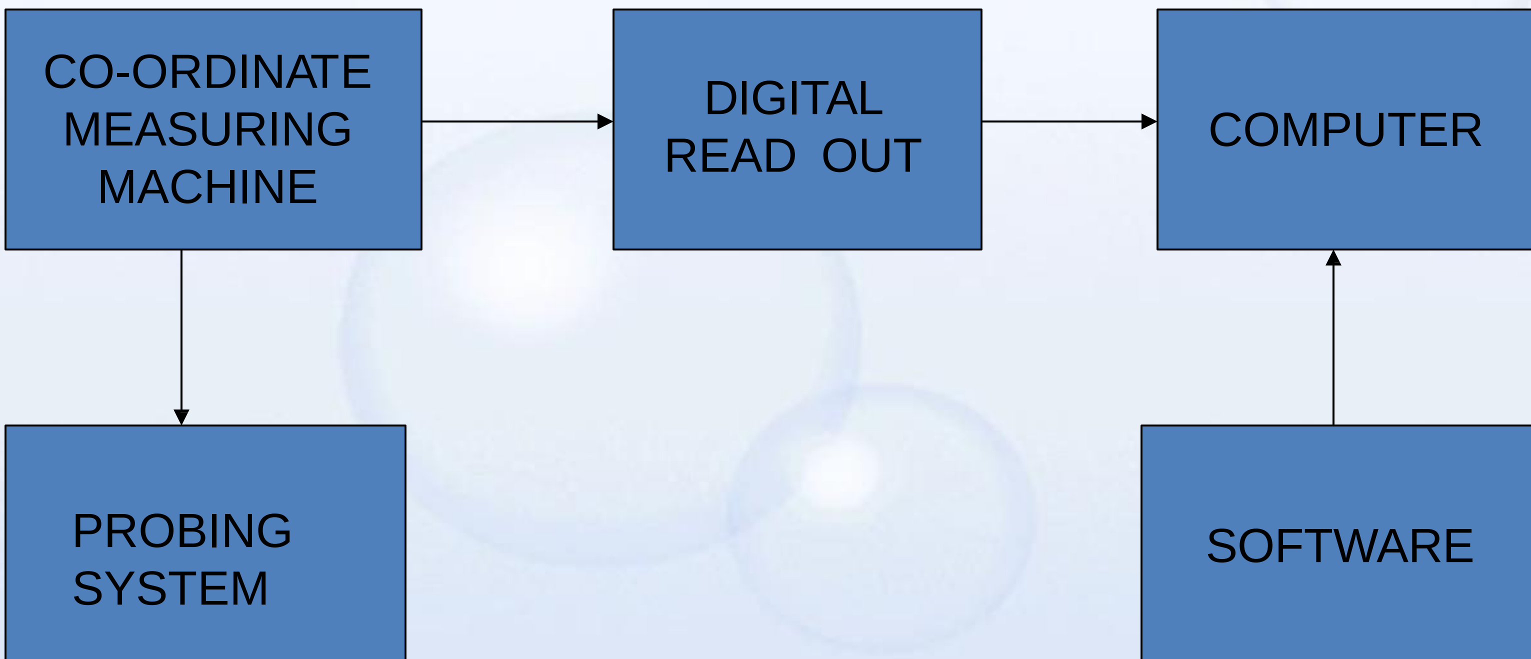
Measurements are defined by a probe attached to the third moving axis of this machine. Probes may be mechanical, optical, laser, or white light, among others.

DESCRIPTION

- The typical "bridge" CMM is composed of three axes, an X, Y and Z. These axes are orthogonal to each other in a typical three dimensional coordinate system.
- Each axis has a scale system that indicates the location of that axis. The machine will read the input from the touch probe, as directed by the operator or programmer.
- The machine then uses the X,Y,Z coordinates of each of these points to determine size and position. Typical precision of a coordinate measuring machine is measured in Microns, or Micrometers, which is 1/1,000,000 of a meter.
- A coordinate measuring machine (CMM) is also a device used in manufacturing and assembly processes to test a part or assembly against the design intent. By precisely recording the X, Y, and Z coordinates of the target, points are generated which can then be analyzed via regression algorithms for the construction of features.
- These points are collected by using a probe that is positioned manually by an operator or automatically via Direct Computer Control (DCC). DCC CMMs can be programmed to repeatedly measure identical parts, thus a CMM is a specialized form of industrial robot.

Coordinate Measuring Machines - Model

BLOCK DIAGRAM OF THE ELEMENTS OF A CMM



Uses

They are often used for:

- Dimensional measurement
- Profile measurement
- Angularity or orientation measurement
- Depth mapping
- Digitizing or imaging
- Shaft measurement

Feature Based Measurement

- **Form**
  - straightness, flatness, roundness, cylindricity, sphericity
- **Orientation**
  - parallelism, perpendicularity, concentricity, angularity
- **Profile**
  - profile (scanning), surface (manual), output (graphics)

ADVANTAGES OF USING CMM

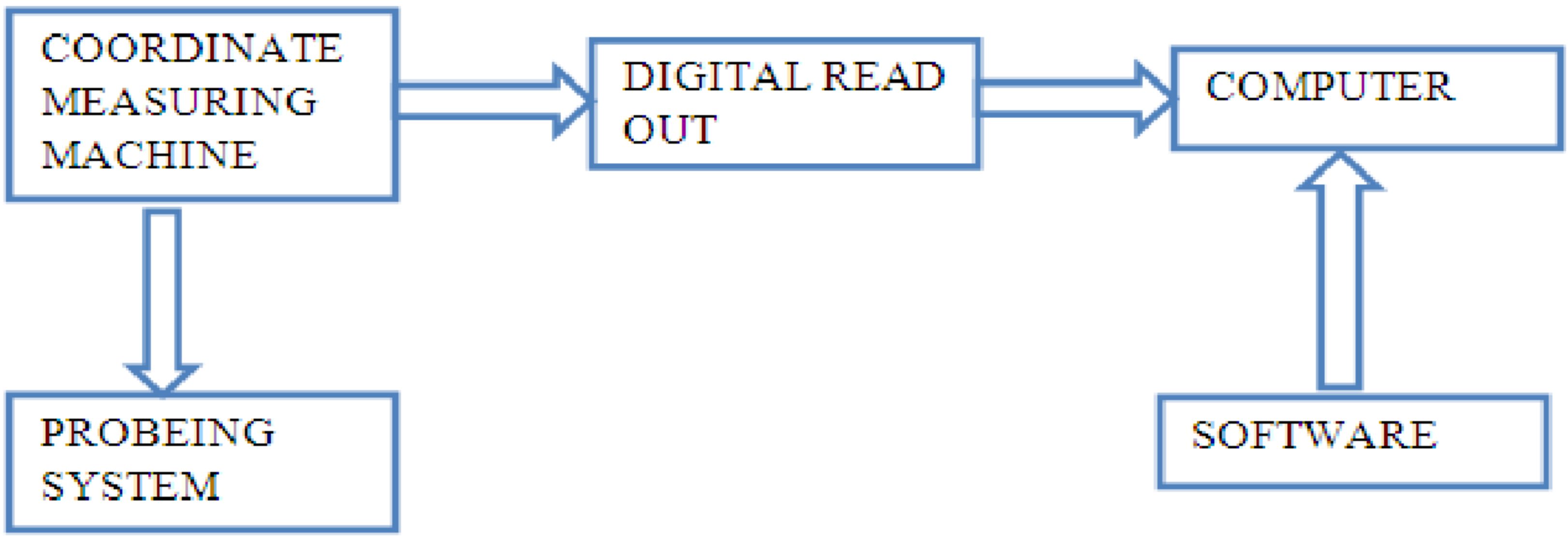
FLEXIBILITY:

- Co-ordinate measuring machines are essentially universal measuring machines and do not need to be dedicated to any single or particular measuring task.
- They can measure practically any dimensional characteristic of virtually any part configuration, including cams, gears, and contoured surfaces.
- No special fixtures or gages are required; because electronic probe contact is light, most parts can be inspected without being clamped to a surface plate.

REDUCED SETUP TIME:

- Establishing part alignment and appropriate reference points are very time consuming with conventional surface-plate inspection techniques.
- These procedures are greatly simplified or virtually eliminated through software available on computer-assisted or computer-controlled CMMs.

BLOCK DIAGRAM OF THE ELEMENTS OF A CMM



A basic Co-ordinate Measuring Machine consists of four elements.

1) The machine structure which is basically an X-Y-Z positioning device.
2) The Probing system use to collect raw data on the part and provide input to the control system.
3) Machine Control and Computer hardware.
4) The Software for three dimensional analyses.

TYPES OF CMM

1. Cantilever type
2. Bridge type
3. Column type
4. Gantry type
5. Horizontal type.

CANTILEVER TYPE

- The probe is attached to the vertical quill that moves in a Z-axis direction relative to a horizontal arm that over hangs the work table.
- The quill can be moved along the length of the arm to achieve y-axis motion, and the arm can be moved to the work table to achieve x-axis motion.

Advantages

- Convenient access to the work table and its relatively small floor space requirements

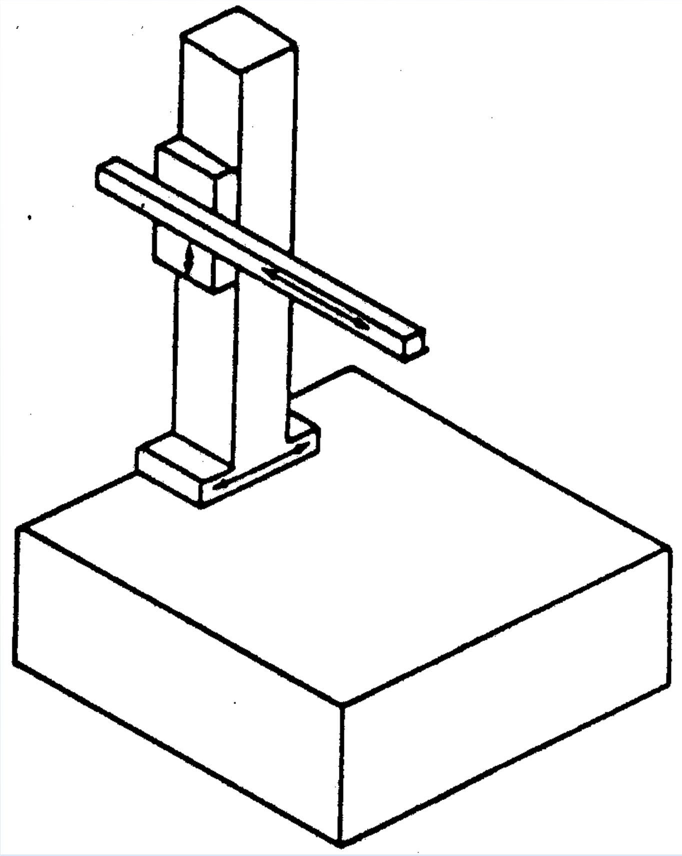
Disadvantages

- Lower rigidity than some of the other CMM construction

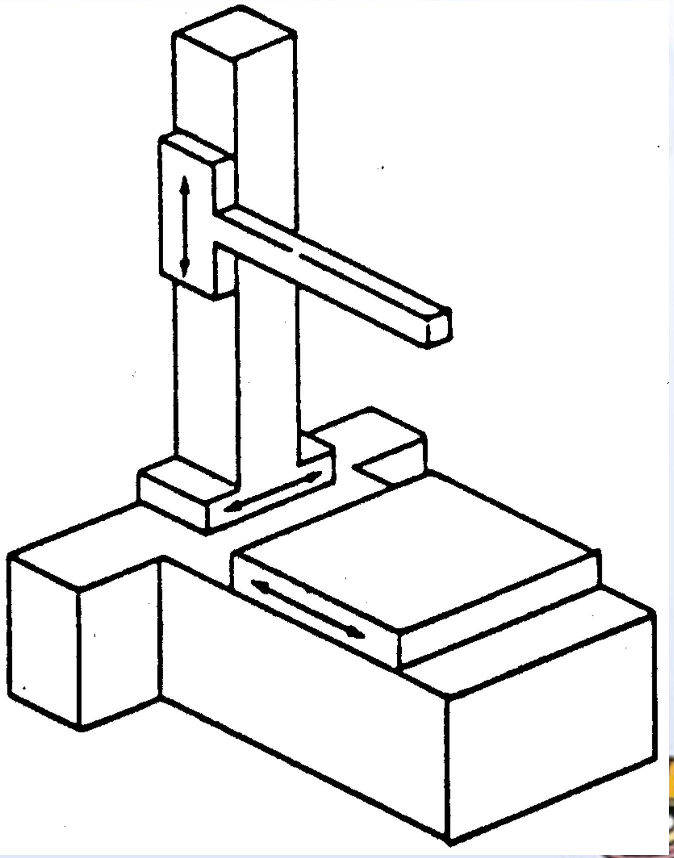
Types of cantilever

1. Moving Table Horizontal Arm CMM
2. Moving Arm Horizontal Arm CMM
3. Column CMM
4. Fixed Table Horizontal Arm CMM

Types of CMM

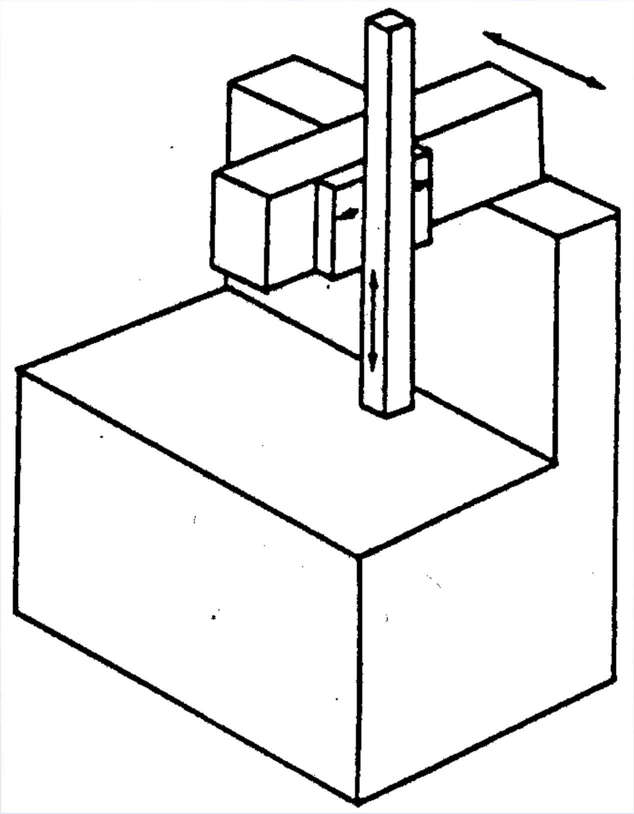


Moving Arm Horizontal Arm Coordinate Measuring Machine

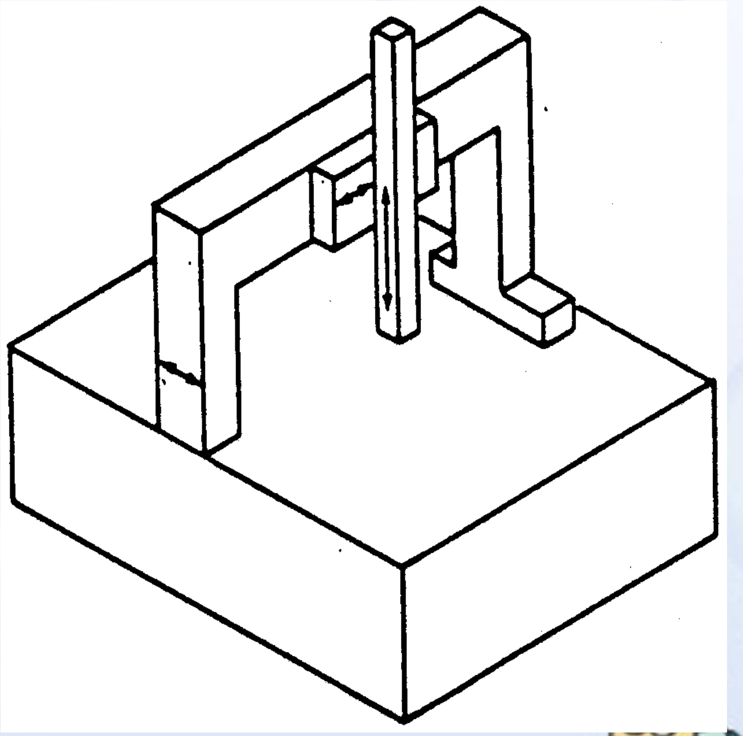


Moving Table Horizontal Arm Coordinate Measuring Machine

Types of CMM



Fixed Table Cantilever Coordinate Measuring Machine



Moving Bridge Coordinate Measuring Machine

BRIDGE:

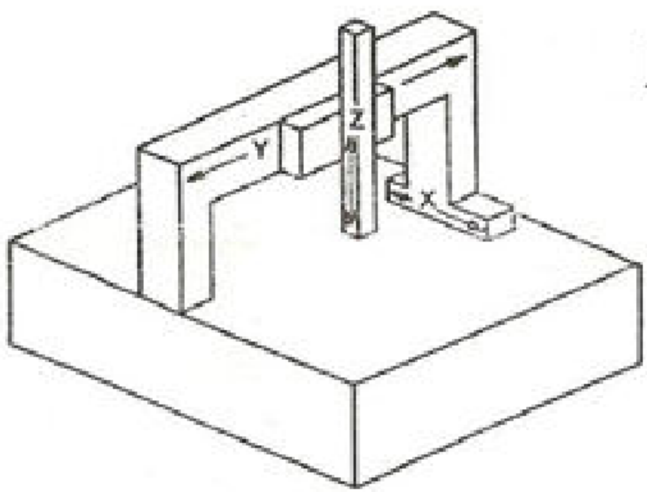
- It is difficult to load but less sensitive to mechanical errors.
- Bridge-type coordinate measuring machines employ three movable components moving along mutually perpendicular guide ways.
- This eliminates pitching and yawing moments on the bridge assembly, allowing higher acceleration and deceleration rates.
- The bridge-type CMM is the most popular configuration.
- The double-sided support of this type of CMM provides more support for large and medium-sized machines.
- The bridge can slide back on the base to give complete accessibility to the working area for safe, easy loading and unloading of parts.

- Traveling-bridge CMMs have longer Y strokes for less cost than do cantilever-type CMMs.

- However, because of the weight of the extra support, the inertia of the moving mass is greater than in the cantilever configuration.

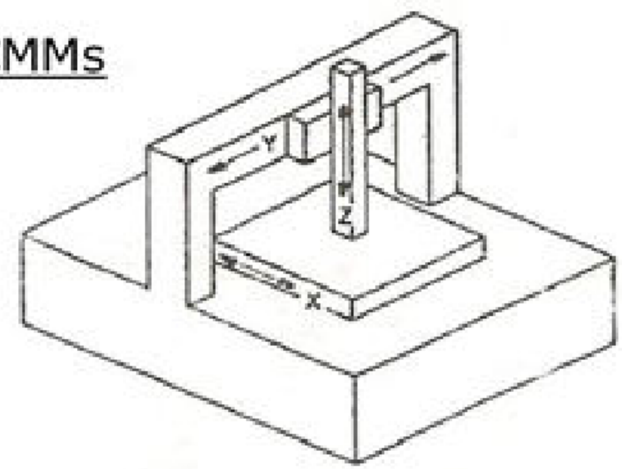
- In addition, the parts being measured with this type of CMM cannot be wider than the clearance between the two sides of the bridges.

<u>Bridge type CMMs</u>



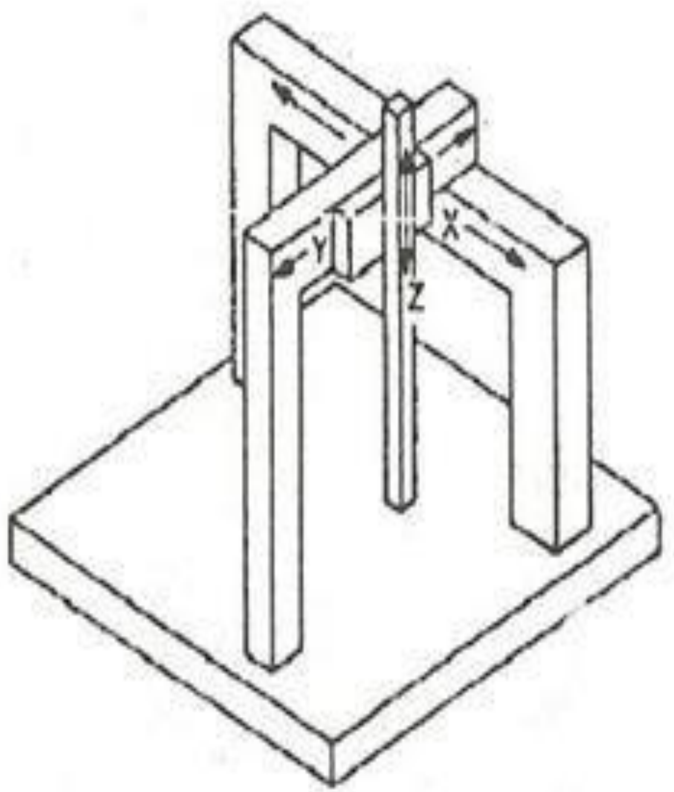
(a)

Moving bridge



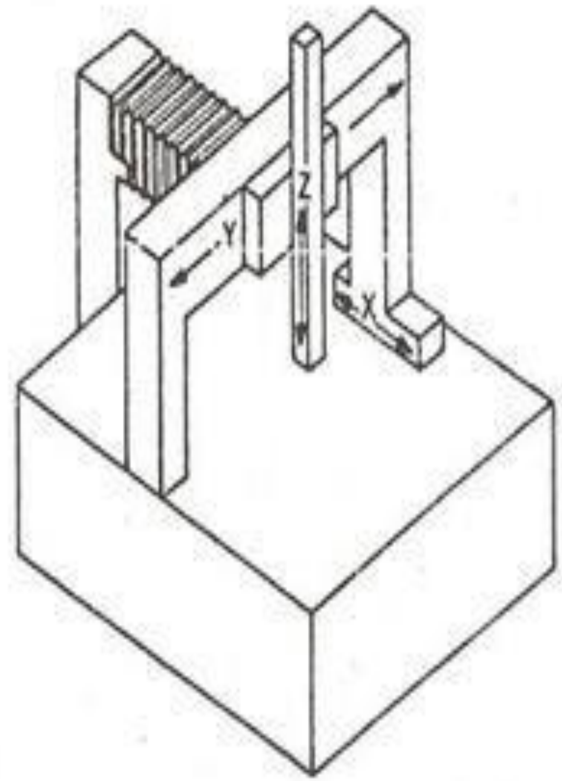
(b)

Fixed bridge



(c)

L-shaped bridge



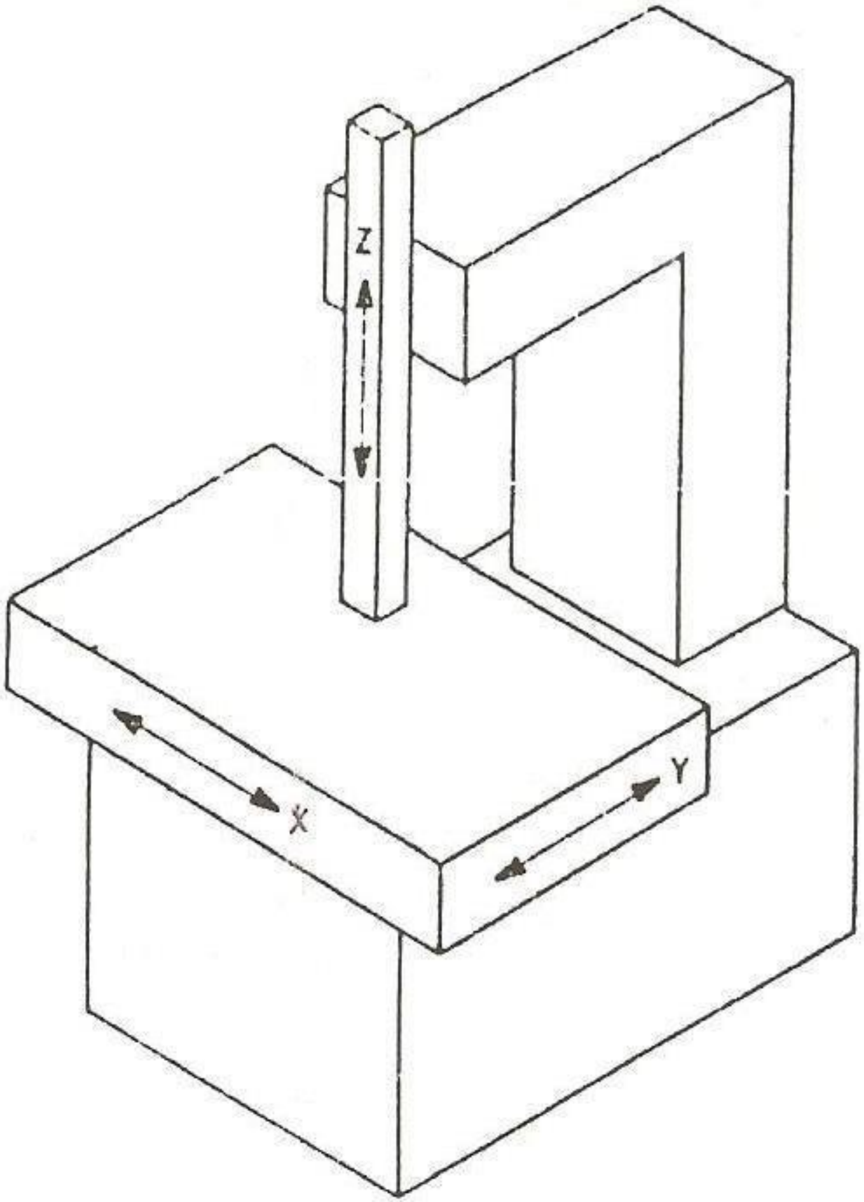
(d)

Central drive bridge

COLUMN:

- Column-type CMMs are similar in construction to accurate jig boring machines.
- The column moves in a vertical (Z) direction only, and a two-axis saddle permits movement in the horizontal (X and Y) direction.
- Column-type CMMs are often referred to as universal measuring machines rather than CMMs by manufacturers and are considered gage-room instruments rather than production-floor m/c.

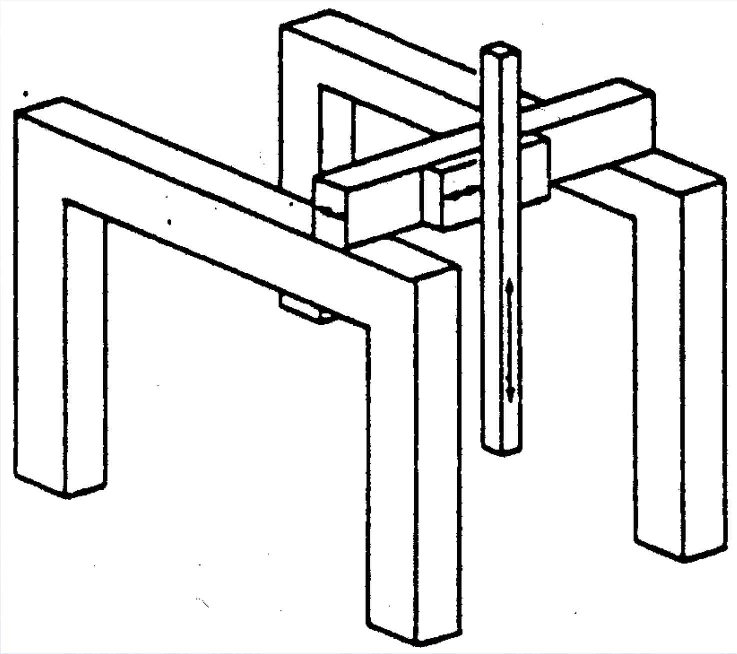
Column-type CMM



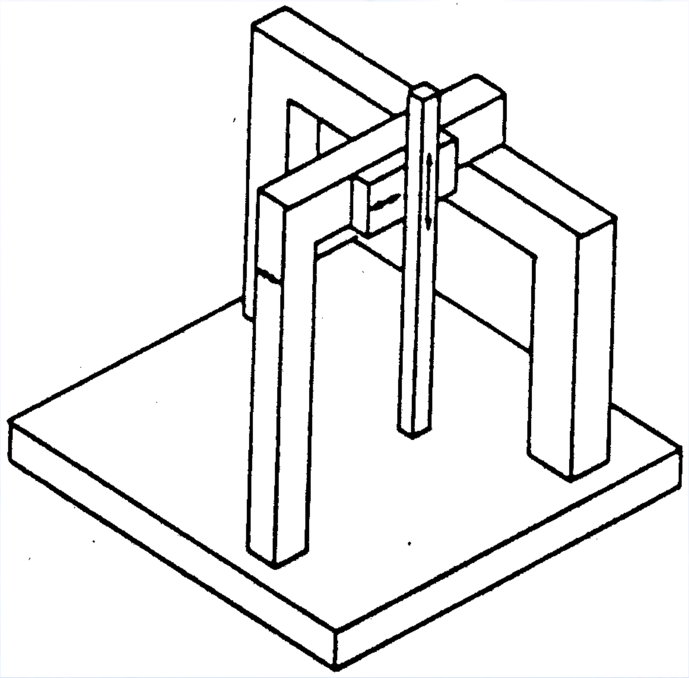
GANTRY:

- Gantry-type CMMs employ three movable components moving along mutually perpendicular guide ways.
- The probe is attached to the probe quill, which moves vertically (Z direction) relative to a cross beam.
- The probe quill is mounted in a carriage that moves horizontally (Y direction) along the cross beam.
- The cross beam is supported and moves in the X direction along two elevated rails, which are supported by columns attached to the floor.
- The gantry-type configuration was initially introduced in the early 1960s to inspect large parts such as airplane fuselages, automobile bodies, ship propellers, and diesel engine blocks.
- The open design permits the operator to remain close to the part being inspected while minimizing the inertia of the moving machine parts and maintaining structural stiffness.

Types of CMM

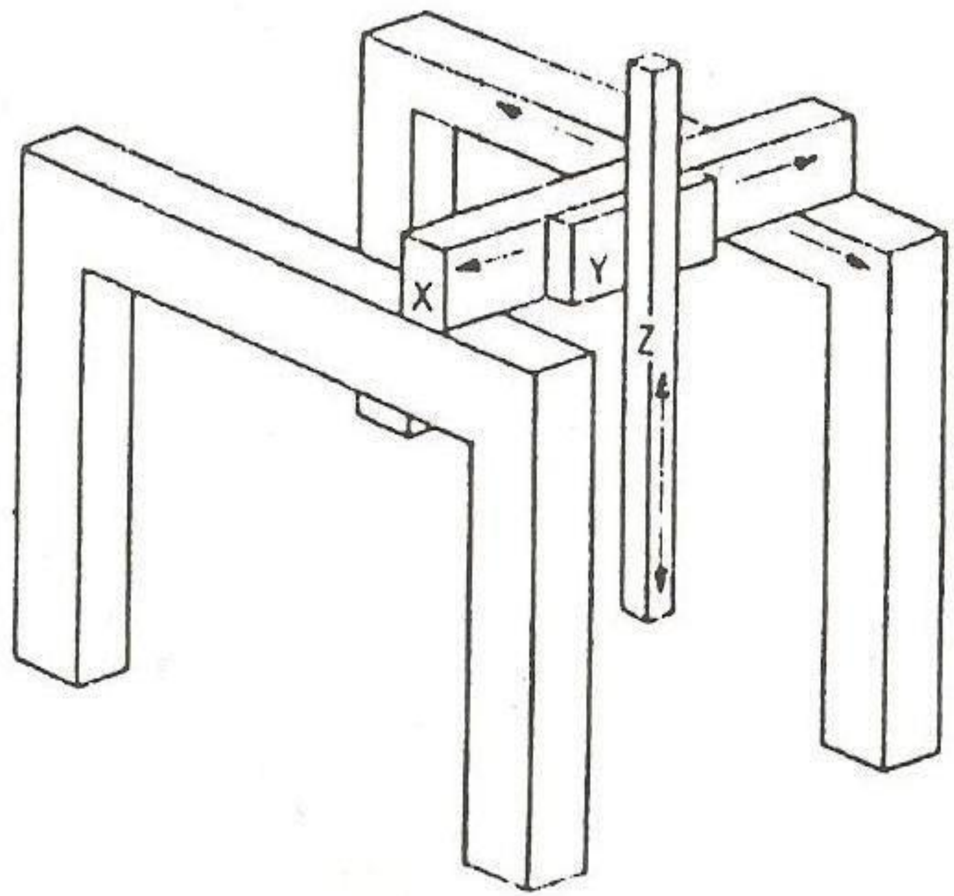


Gantry Coordinate Measuring Machine



L-shaped Bridge Coordinate Measuring Machine

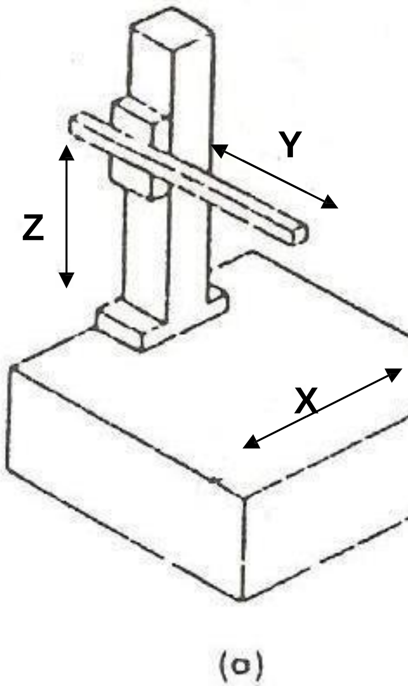
Gantry-type CMM



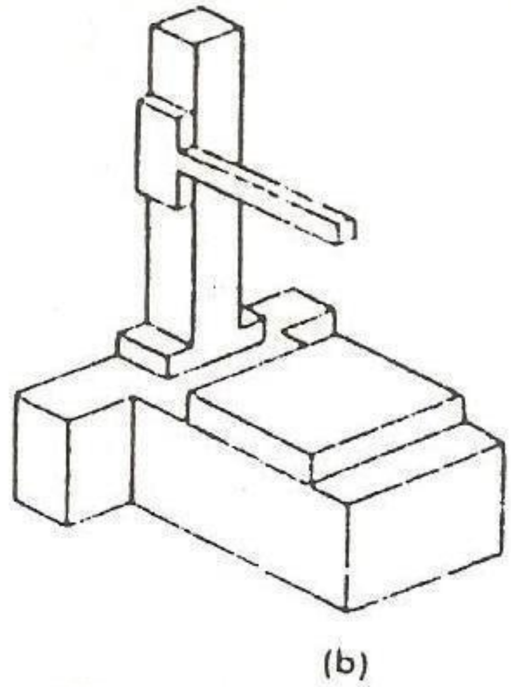
HORIZONTAL ARM:

- Several different types of horizontal arm CMMs are available.
- As is typical of all CMMs, the horizontal arm CMMs employ three movable components moving along mutually perpendicular guideways.
- The probe is attached to the first component, which moves vertically (Z direction) relative to the second.
- The second component moves horizontally (Y direction) relative to the third. The third component is supported on two legs that reach down to opposite sides of the machine base and moves horizontally (X direction) relative to the base.
- Another modification of the bridge configuration has two bridge-shaped components.
- One of these bridges is fixed at each end to the machine base. The other bridge, which is an inverted L-shape, moves horizontally (X direction) on guideways in the fixed bridge and machine base.
- A third modification of moving-bridge configuration is the central-bridge drive. The drive forces are applied to the center of mass of the bridge assembly.
- This configuration employs three movable components moving along mutually perpendicular guideways. In the moving-arm design, the probe is attached to the horizontal ram, which moves in a horizontal Y direction.

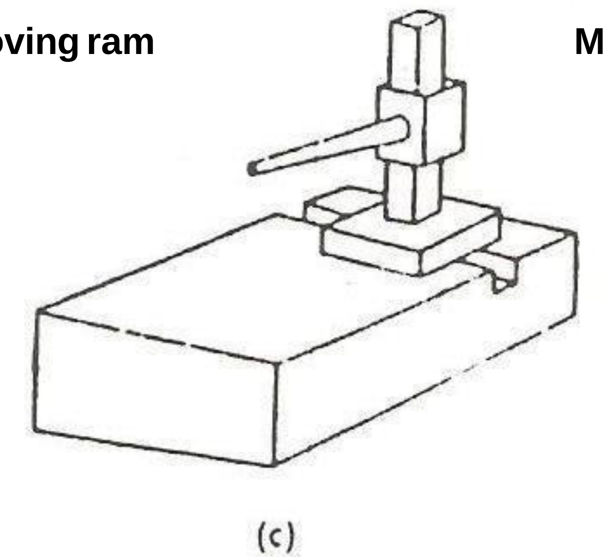
Horizontal arm CMMs



Moving ram



Moving table



Fixed table

- The ram is encased in a carriage that moves in a vertical (Z) direction and is supported on a column that moves horizontally (X direction) relative to the base.

- In the moving-table design, the probe is attached to the horizontal arm, which is permanently attached at one end only to a carriage that moves in a vertical (Z) direction on the column.

- The arm support and table move horizontally (X and Y directions) relative to the machine base.

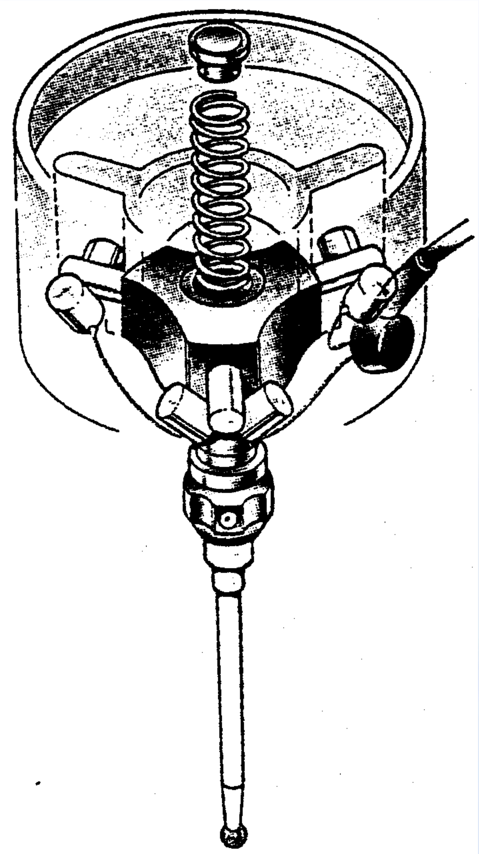
- In the fixed-table design, the probe is attached to the horizontal arm, which is supported cantilever style at the arm support and moves in a vertical (Z) direction.

- The arm support moves horizontally (X and Y directions) relative to the machine base.Horizontal arm CMMs are used to inspect the dimensional and geometric accuracy of a broad spectrum of machines or fabricated workpieces.

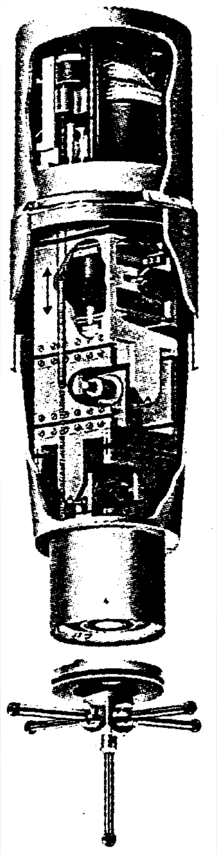
- Utilizing an electronic probe, these machines check parts in a mode similar to the way they are machined on horizontal machine tools.

- They are especially suited for measuring large gear cases and engine blocks, where high-precision bore alignment and geometry measurements are required.By incorporating a rotary table, four-axis capability is obtainable.

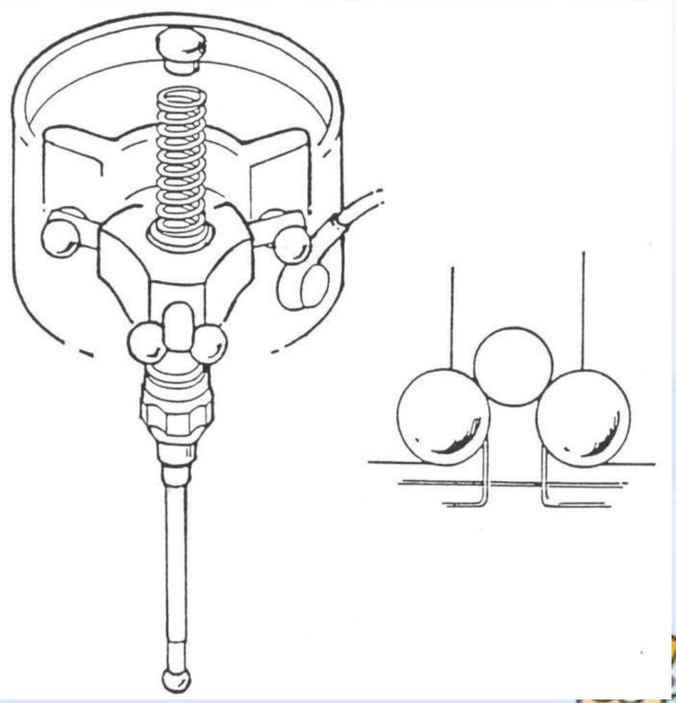
Probe Systems



Switching probe system



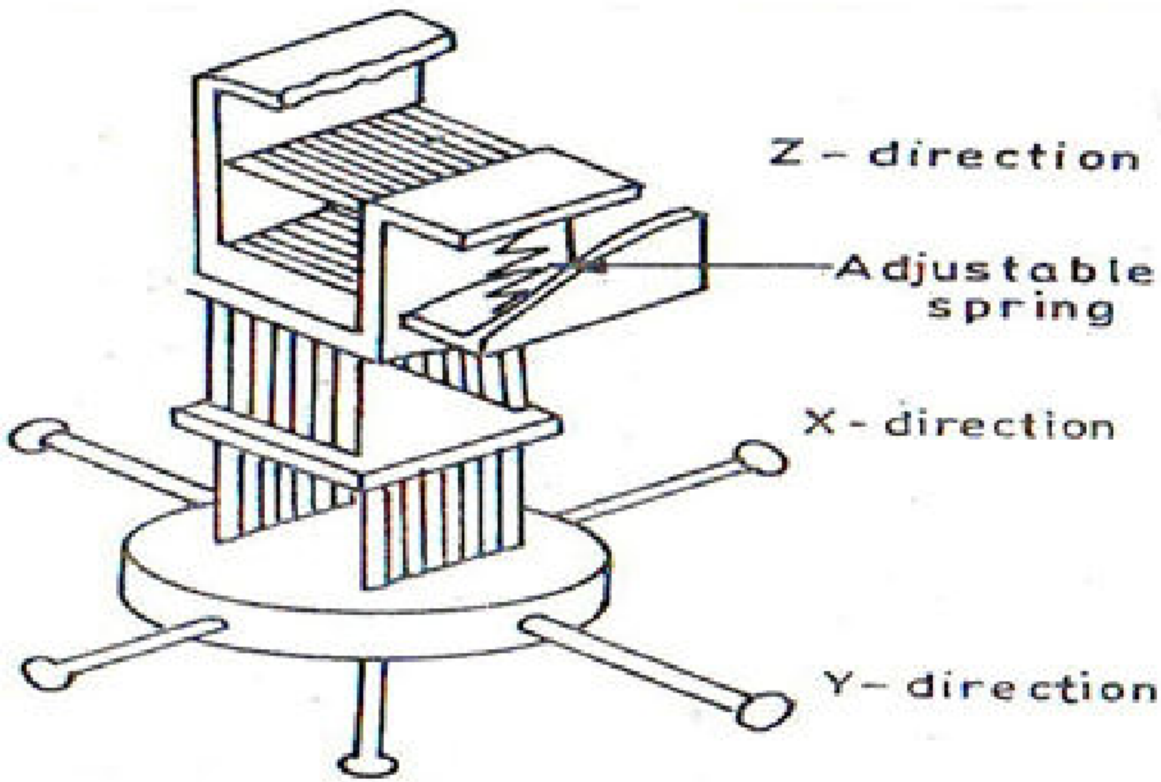
Continuous measuring probe system



Kinematic touch trigger probe

2. Measuring type probe system:

- Measuring type probe mechanism is a small co-ordinate measuring machine in itself.The "buckling mechanism" of this system consists of parallel guide. At the moment of probing, the spring parallelograms are deflected from their initial position.
- The measurements can be made easily because the entire system is free from torsion, play and friction. A defined parallel displacement of probes as compared to their original arrangements can be measured.



NONCONTACT PROBES:

- Noncontact probes are used when fast, accurate measurements are required with no physical contact with the part. Several types of noncontact probes are used.
- Optical probes are used when inspecting drawings, printed circuit boards, and small, fragile workpieces. When these probes are used, the basic measuring programs can still be used.

    1. TOUCH SCANNERS
    2. LASER PROBES
    3. VISION PROBES

ADVANTAGES OF CMM

1. Faster rate of inspection
2. Improved accuracy
3. Minimisation of operator error
4. Reduced operator skill requirements
5. Reduced need of fixtures and maintenance costs
6. Uniform inspection quality
7. Reduction of scrap
8. Reduction in setup time
9. Simplification of inspection procedures.
10. Reduction in calculating and recording time and errors

COMPUTER SOFTWARE

- Although the computer is the heart of the CMM, it is the software that enables the systems to fulfil the potential.
- A family of software that allows the transfer of data between CMMs and CAD systems, and other programs are available that facilitate the communication of data between CAD systems made different manufactures.
- Development in this area has been so dynamic that standard for data format have already been developed and accepted by the industry. Such as Dimensional measurements interface specification for communication from CMMs to CAD system and initial graphics specification for CAD to CAD data exchange.
- Such integration makes possible the use of CMMS in a variety of new applications, such as for reverse engineering in which specifications are derived from the measurements of a model or a broken art, and for the development of part programs

Machine Vision System

What is a Machine Vision System?

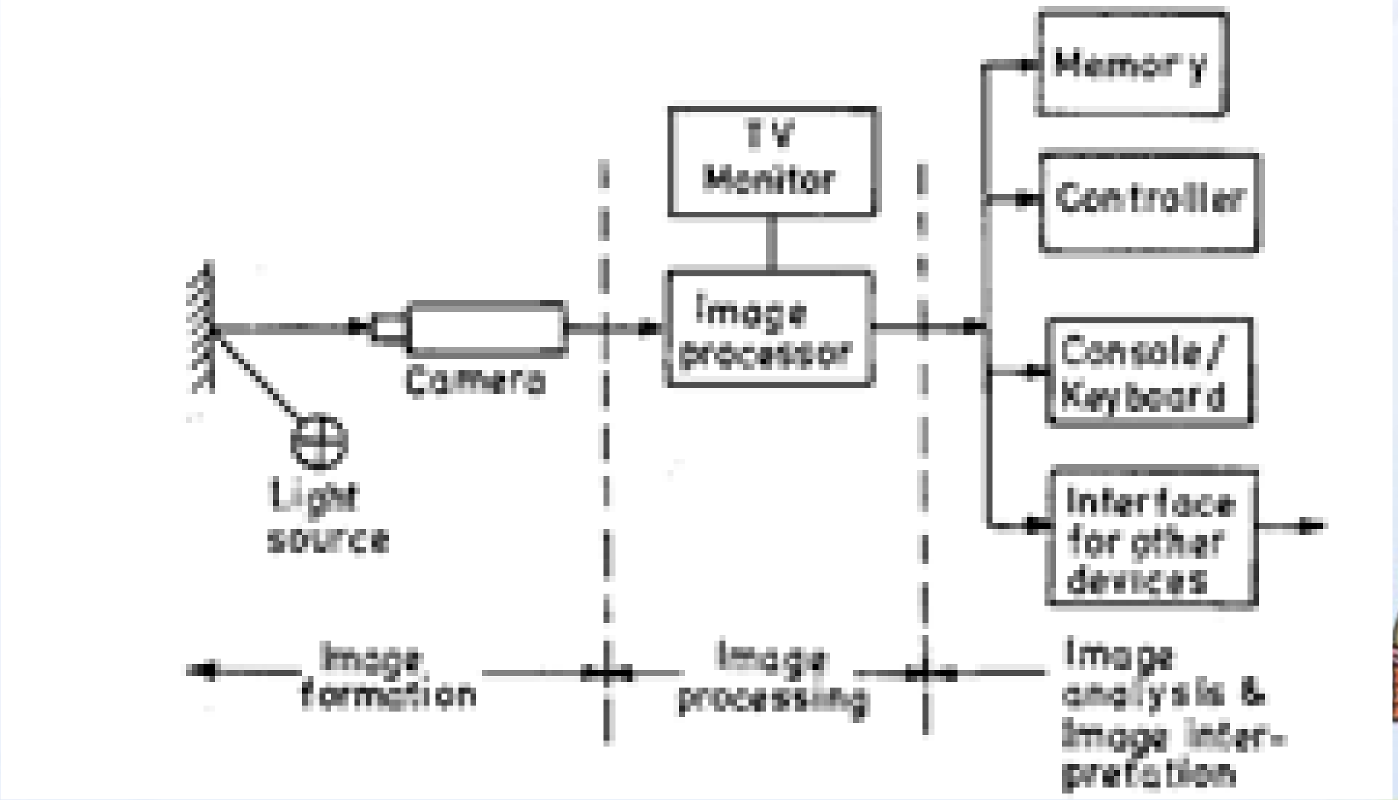
- **Machine vision (also sometimes called computer vision or intelligent vision), can be defined as a means of simulating the image recognition and analysis capabilities of the human eye/brain system with electronic and electromechanical techniques.**

- **In human vision system, eyes sense the image and brain analyses the information and takes action on the basis of analysis. Similarly in machine vision system, visual sensing of information is done after forming an image of the object and information is analysed to make a useful decision about its content. Machine vision system thus needs both visual-sensing and interpretive capabilities.**

- **Image sensing device may consist of vidicon camera or a charge-coupled device (CCD) image sensor. It receives light through a lens system and converts this light into electrical signals. Micro-computers are used to refine and analyse these electrical signals to provide an interpretation of the object that generates these signals.**

The machine vision system involves following four basic steps:

- (i) Image formation
- (ii) Processing of image in a form suitable for analysis by computer
- (iii) Defining and analysing the characteristics of image
- (iv) Interpretation of image and decision making.



(i) Image formation.

For formation of image suitable light source is required. It may consist of incandescent light, fluorescent tube, fiber-optic bundle, arc lamp, or strobe light. Laser beam is used for triangulation system for measuring distance. Polarised or ultraviolet light is used to reduce glare or increase contrast

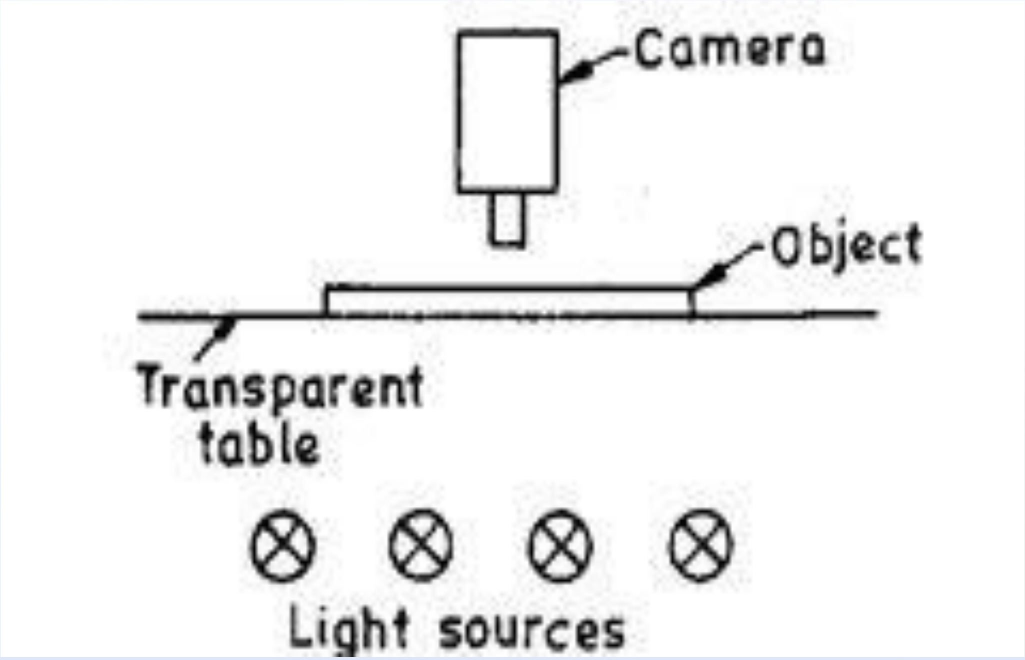


IMAGE PROCESSING.

(a) Windowing. This technique is used to concentrate the processing in the desired area of interest and ignoring other non-interested part of image. An electronic mask is created around a small area of an image to be studied. Thus only the pixels that are not blocked out will be analysed by the computer.

(b) Image Restoration. This involves preparation of an image in more suitable form during the pre-processing stage by removing the degradation suffered. The image may be degraded (blurring of lines/boundaries; poor contrast between image regions, presence of background noise, etc.) due to motion of camera/object during image formation, poor illumination/poor placement, variation in sensor response, poor contrast on surface, etc.).

- The quality may be improved, (i) by improving the contrast by constant brightness addition, (ii) by increasing the relative contrast between high and low intensity elements by making light pixels lighter and dark pixels darker (contrast stretching) or (iii) by Fourier domain processing.

IMAGE ANALYSIS

- Digital image of the object formed is analysed in the central processing unit of the system to draw conclusions and make decisions.

- Analysis is done by describing and measuring the properties of several image features which may belong to either regions of the image or the image as a whole.

- Process of image interpretation starts with analysis of simple features and then more complicated features are added to define it completely.

- Analysis is carried for describing the position of the object, its geometric configuration, and distribution of light intensity over its visible surface, etc.

- Three important tasks performed by machine vision systems are measuring the distance of an object from a vision system camera, determining object orientation, and defining object position.

- The distance of an object from a vision system camera can be determined by stadimetry (direct imaging technique, in which distance is judged by the apparent size of an object in the field of view of camera after accurate focusing

IMAGE INTERPRETATION

- Image interpretation involves identification of an object based on recognition of its image.

- Various conclusions are drawn by comparing the results of the analysis with a presorted set of standard criteria.

- In a binary system, the image is segmented or windowed on the basis of clustering of white and black pixels.

- Then all groups of black pixels within each segment (called blocks) and groups of white pixels (called holes) are counted and total quantity is compared with expected numbers to determine how closely the real image matches the standard image.

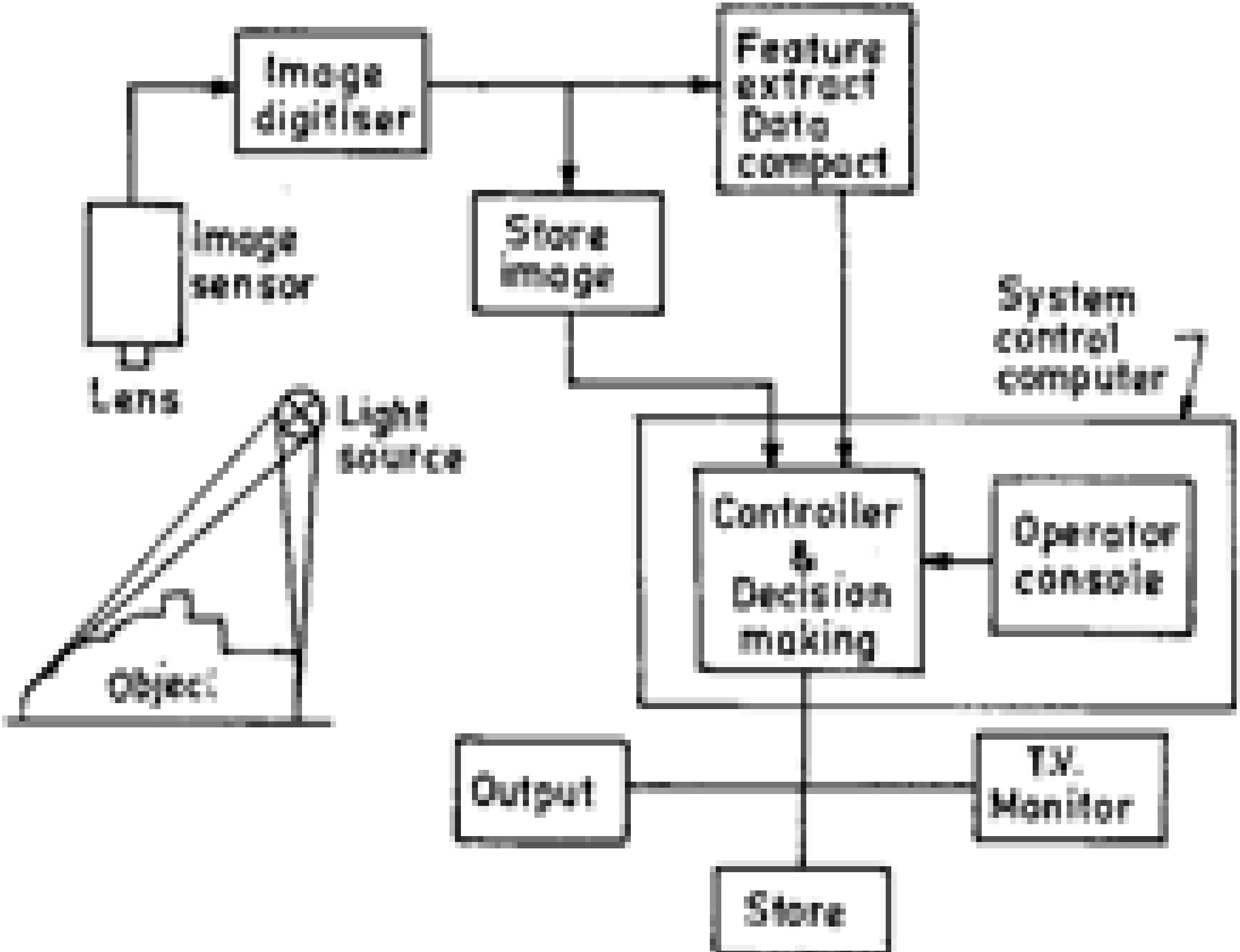


Image digitiser
Feature extract Data compact
Image sensor
Store image
Lens
System control computer
Light source
Controller & Decision making
Operator console
Object
Output
T.V. Monitor
Store

MACHINE VISION SYSTEM APPLICATIONS

The machine vision could be used for:

(a) **Inspection**. The ability of an automated vision system to recognise well-defined patterns and determine if these patterns match those stored in the system makes machine vision ideal for inspection of raw materials, parts, assemblies, etc.

(b) **Part identification**. Machine vision systems due to their ability of part recognition provide positive identification of an object for decision making purposes.

Part identification applications of machine vision systems range from the familiar optical character recognition process to part sorting and bin picking operations.

(c) **Guidance and Control**. Machine vision systems are being used to provide sensory feedback for real-time guidance and control applications, ranging from visual servoing of industrial robots and weld seam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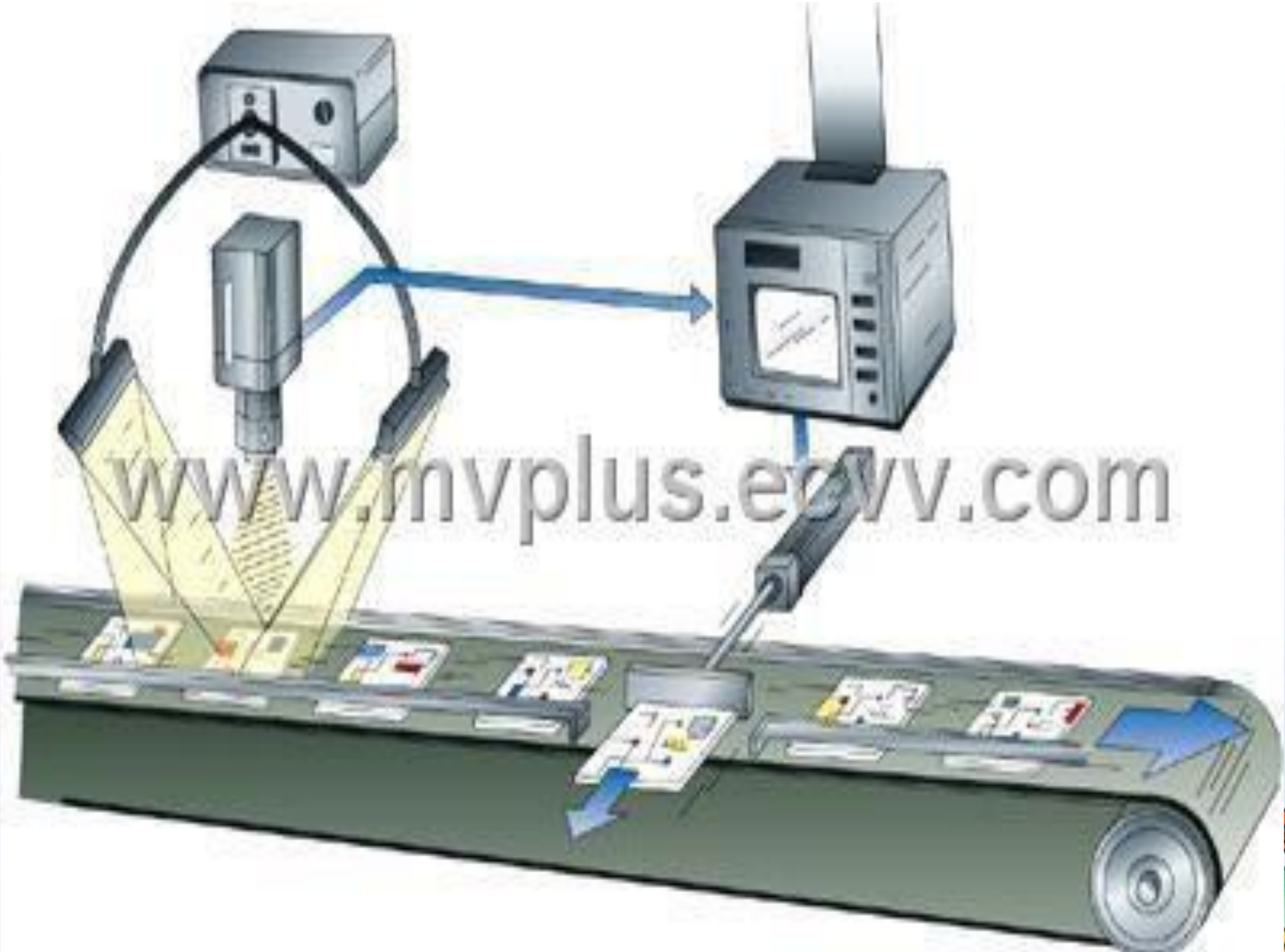
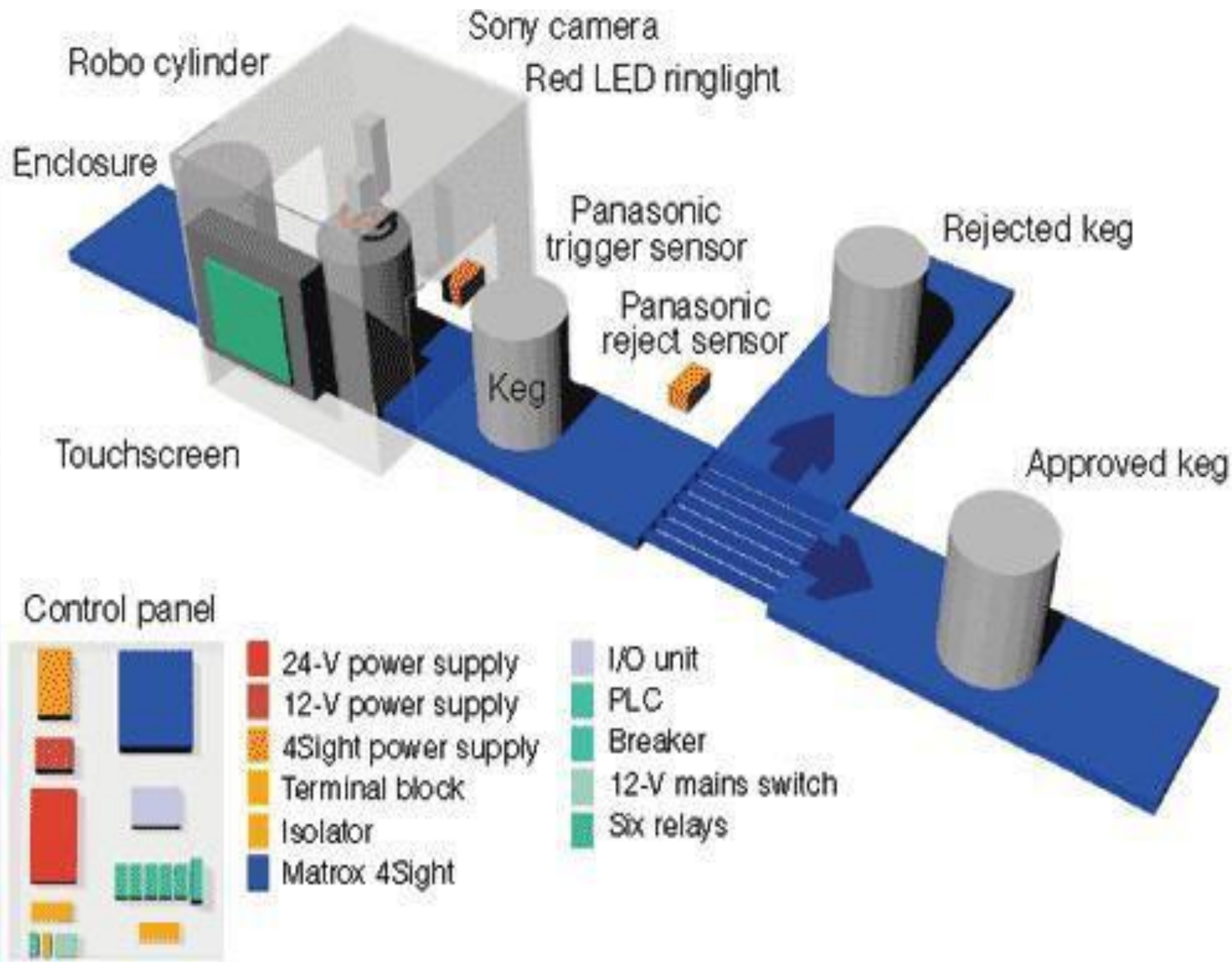
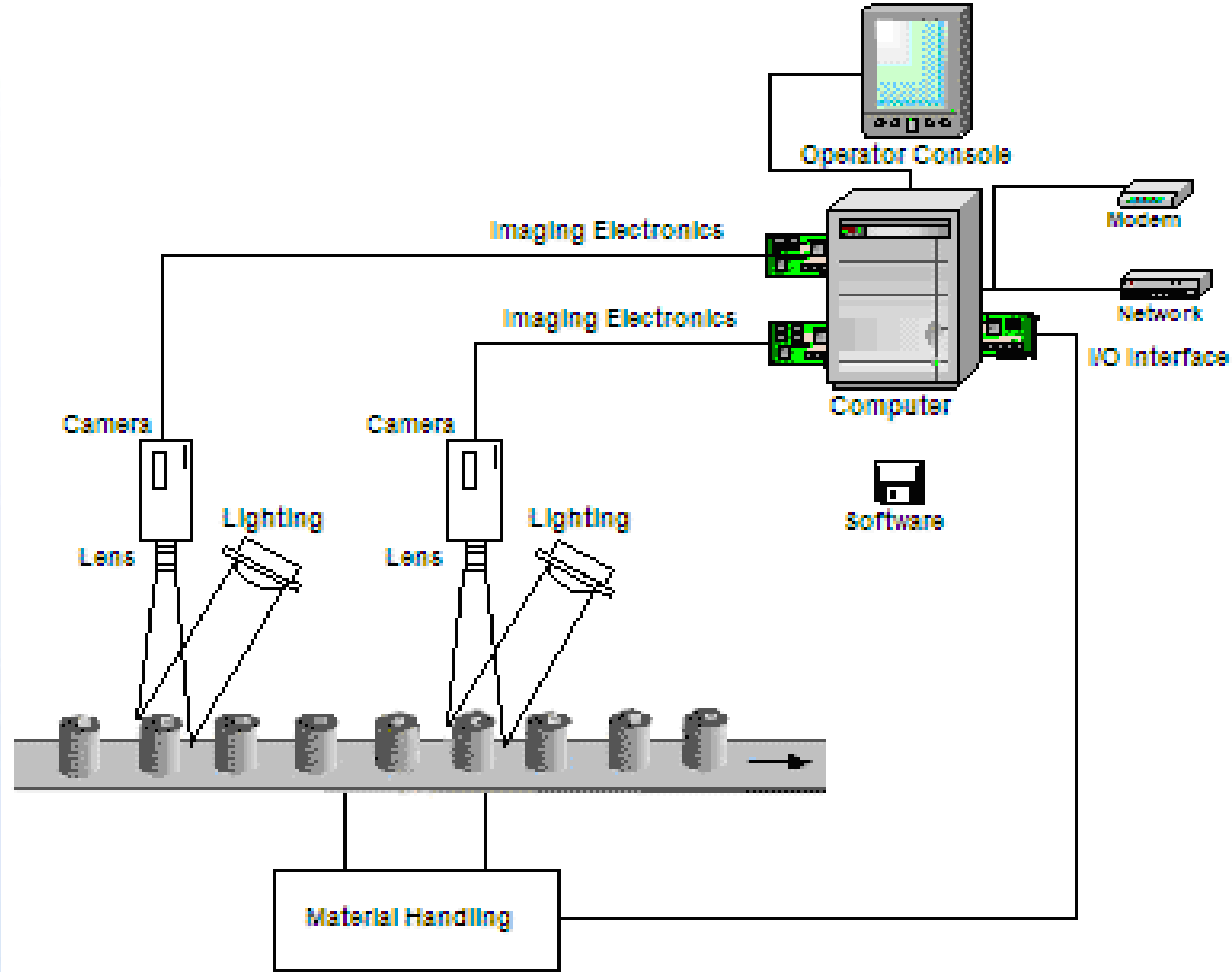
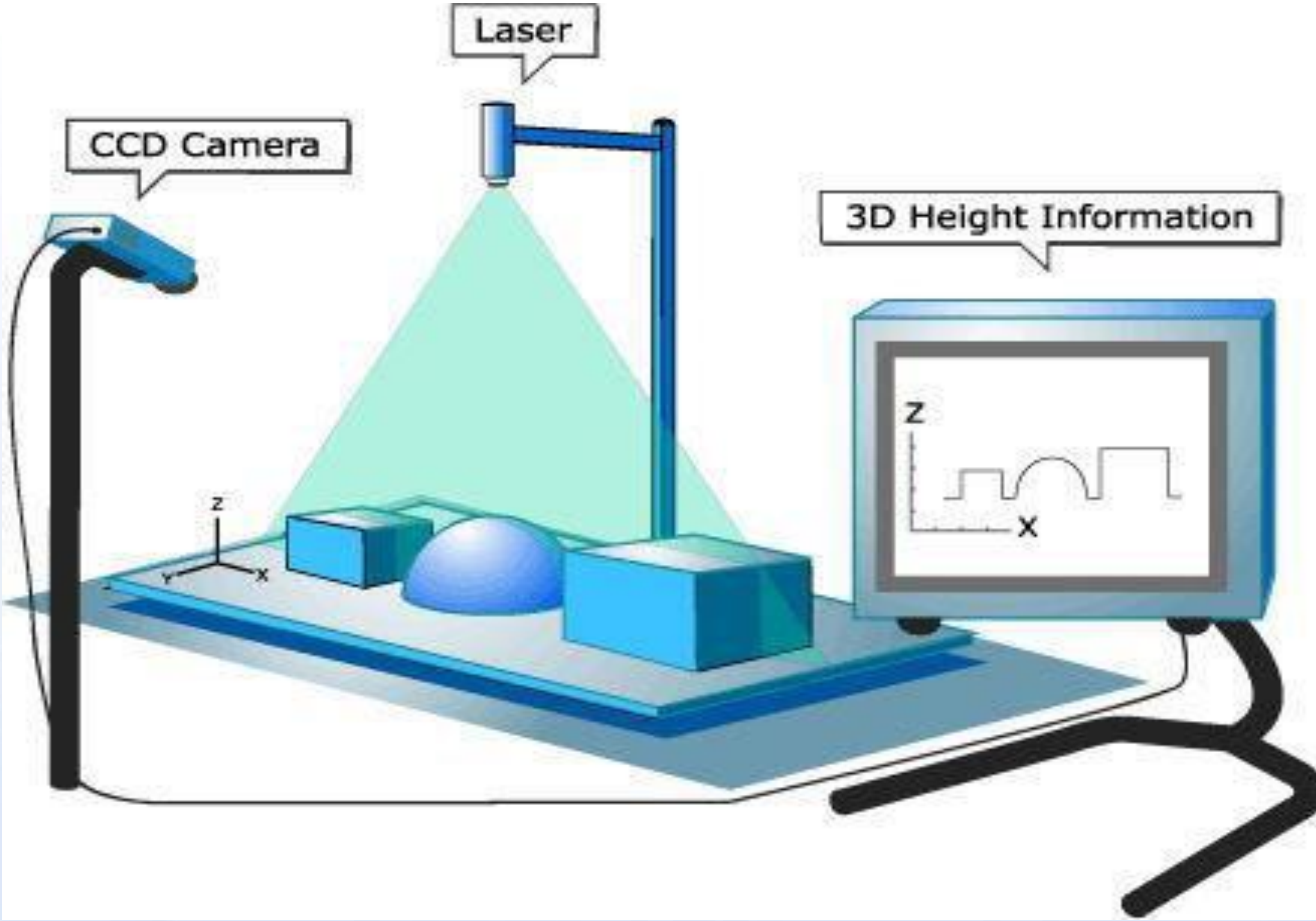

www.mvplus.ecvv.com



Sony camera
Robo cylinder
Red LED ringlight
Enclosure
Panasonic trigger sensor
Rejected keg
Panasonic reject sensor
Keg
Touchscreen
Approved keg
Control panel
24-V power supply
12-V power supply
4Sight power supply
Terminal block
Isolator
Matrox 4Sight
I/O unit
PLC
Breaker
12-V mains switch
Six relays


Operator Console
Imaging Electronics
Imaging Electronics
Modem
Network
I/O Interface
Computer
Camera
Camera
Software
Lighting
Lighting
Lens
Lens
Material Handling


Laser
CCD Camera
3D Height Information
Z
X
z
y
x

Thank You