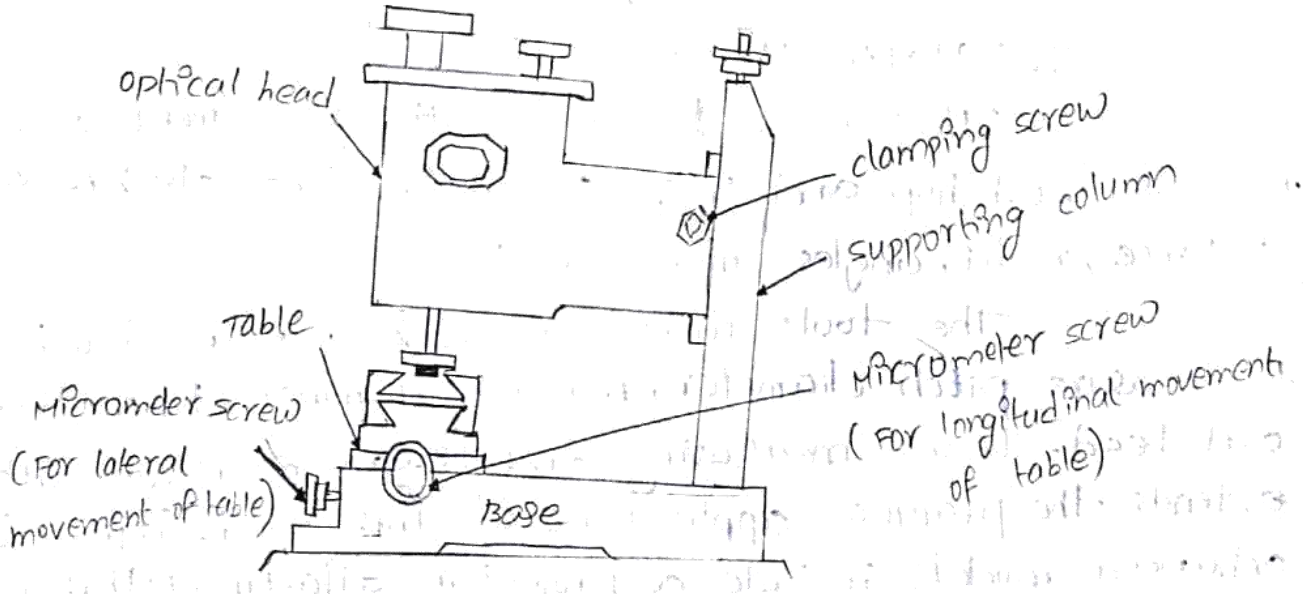
Tools Maker's Microscope :-

The tool maker's microscope is a versatile instrument that measures by optical means with no pressure being involved. It is thus a very useful instrument for making measurements on small and delicate parts.

The tools maker's microscope is designed for the following measurements ie, measurements on part of complex from. for example, the profile of external threads as well as for tools, templates and guages, measuring centre to centre distance of hole in any plane and other wide varifety of linear measurement and accurate angular measurements.

A tool maker's microscope is as shown in below figure. The optical head can be moved up (or) down the vertical column and can be clamped at any height by means of a clamping screw. The lable which is mounted on the base of the instrument can be moved in two mutually perpendicular horizontal directions. by means of accurate micrometer screws having thimble scale

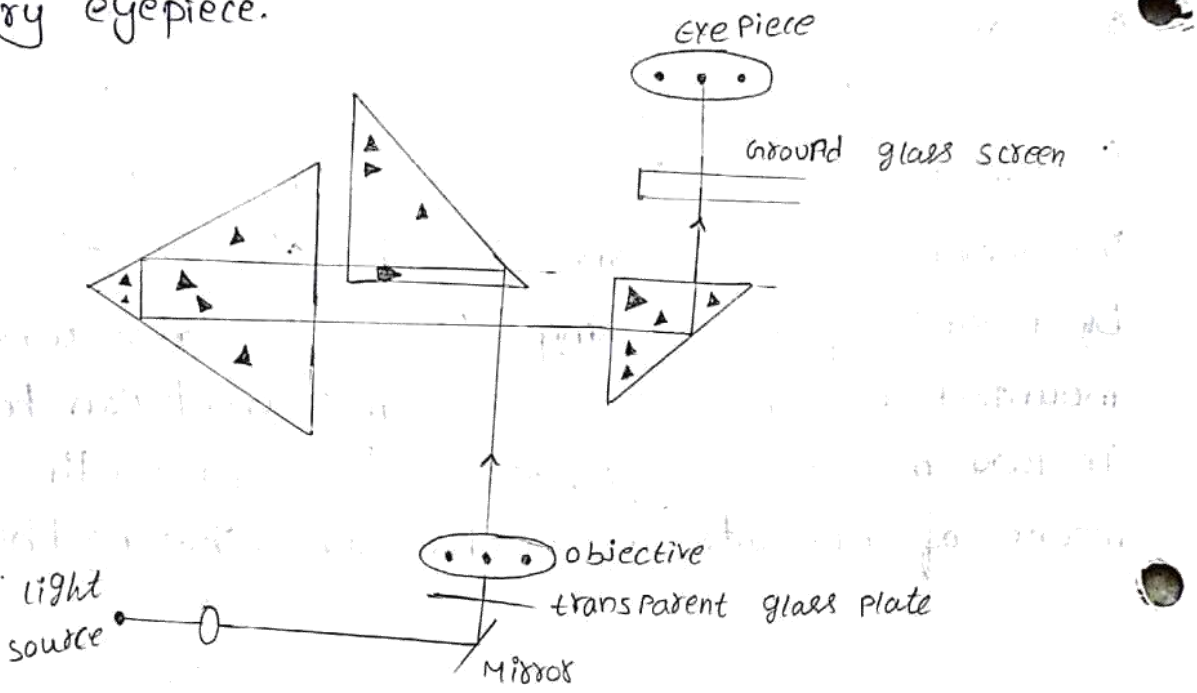


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and Verniers

A ray of light from a light source is as shown in fig(2) is reflected by a mirror through 90°. It then passes through a transparent glass plate. A shadow image of the outline (or) Contour of the workpiece passes through the objective of the optical head and is projected by a system of three prisms to a ground glass screen.

Observations are made through an eye piece. Measurements are made by means of cross-lines engraved on the ground glass screen. The screen can be rotated through 360°, the angle of rotation is read through an auxiliary eyepiece.



Uses of Toll Maker's MicroScope

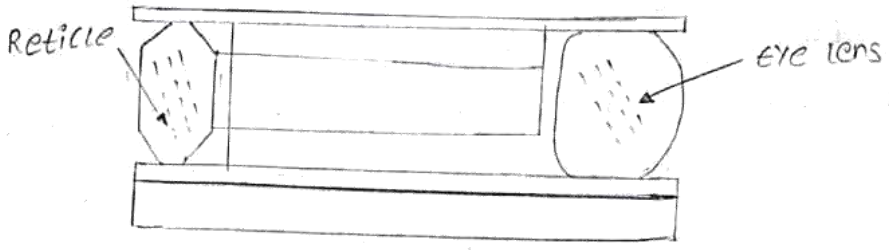
This is a highly versatile instrument and it is used in workshop and inspection areas like checking shoulder distance, radii, angles and form tools.

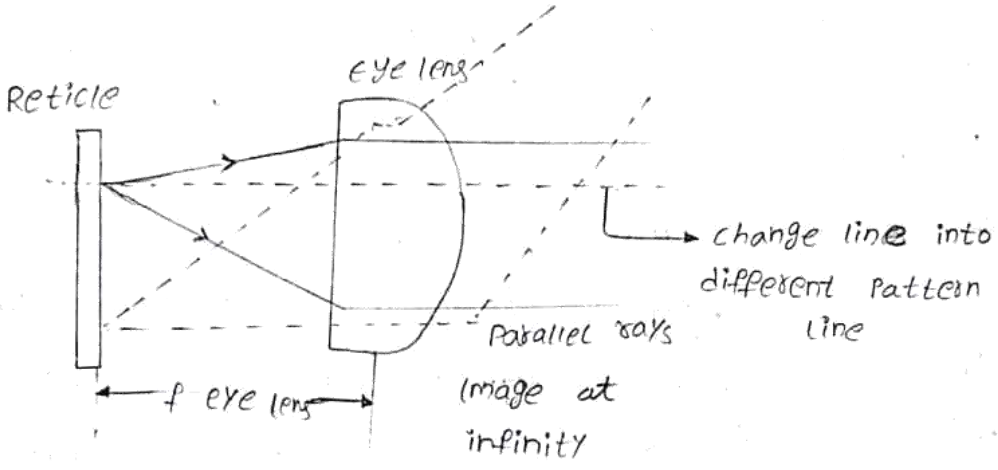
The tools maker's microscope may also be used to measure pitch diameter, major and minor diameters, pitch and lead. Lead-measuring and thread-measuring attachments extends the practical applications of this microscope. Some advanced models include a projection attachment that permits making contour and other precision measurements normally.

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Collimator

Collimator is an optical instrument originated from the telescope. Collimators are assemblies of optical lens that receive convergent or divergent light rays as input and deliver parallel light rays as output.





Working

A reticle which is placed very close to the observer is optically transferred to a position, infinitely distant from the observer. As there are two optical elements a reticle is placed on a ground glass window. The complete arrangement can be incorporated in a compact tube. The eye lens delivers parallel rays and it is called as a collimating lens.

The eye lens allows observations of the reticle at infinity for sighting the target. An opaque coating is applied inside the ground glass window, excluding an uncoated vertical line or centre cross through which diffused light can enter and viewed through the eye lens as a cross or vertical line of

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Light. This cross or vertical line of light is called as a reticle. for infinity adjustments, the cross or vertical line of light is placed in the principle focal plane of the eye lens.

When Collimator used as the sighting device for a weapon, the amount of collimator levelling mechanism is employed with and scales which allows the weapon to be situated at a particular location with relation to the line of sight developed by the collimator

Advantages :-

Light Standard defines length in terms of a standard The advantages of light standards of wavelength are,

1. They are constant
2. They are reproducible anywhere in the world.
3. They do not depend on reference to some particular and possibly vulnerable metal piece.

Their advantages are a major criteria for any standard. It became possible, since, at a constant temperature and pressure each pure color of light from a vaporization element has a specific and constant wavelength

Advantages of Linear Measurement using optical instruments :-

The light beam has the following advantages,

1. Straightness
2. Weightlessness
3. No physical contact with the measurement (as in machanical type).
4. Accuracy obtained through optical instrument is more, when compared with other measuring instruments.

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5. As there is no physical Contact between the optical instruments and the work is being measured, therefore no chance of spoilage of the work or the optical instrument.

6. Easy installation for inspection

7. Compact in size and the optical instoruments are portable.

Limitations of using Optical Instruments

1. A point source can never give a point image due to diffraction of light. It instead gives an image in the form of a circular disc of an angular radius equal to λ/d.

where,

λ = Wavelength of light and

d = Diameter of the telescope or some other optical instrument.

2. Diffraction is the basic limitation on the resolving power of optical instruments like, microscopes and telescopes.

3. The lens of optical flat, it is difficult to control its way and there by orient the fringes to the best advantages

4. The lens of potical instruments may fail due to chromatic aberration, spherical aberration and f-number.

In Optical flat, the fringe pattern is not viewed from above directly, resulting obliquity which leads to errors in viewing and distortion.

Optical projectors

The optical Comparators which make use of the enlarged image principle are Commonly known optical projectors. It is a versatile instrument widely used in many phases of Quality Control and production and has become almost a necessity in the well-equiped tool room.

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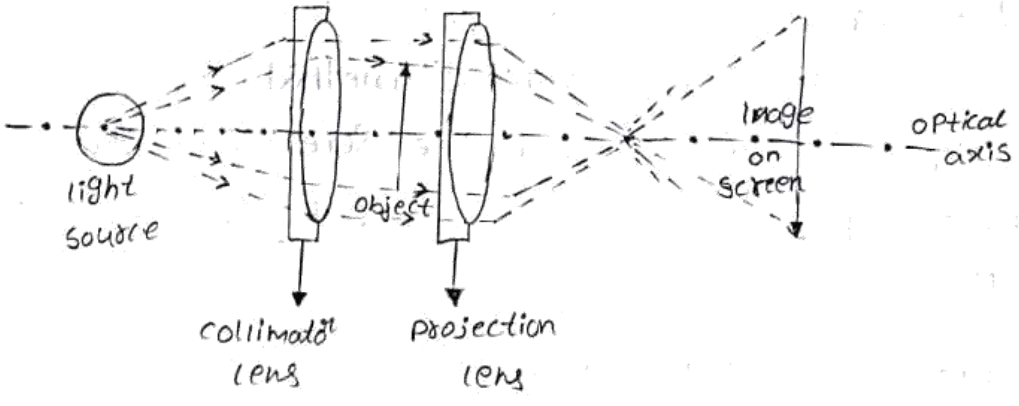
The various types of Optical projectors are as follows:

1. Contour projectors
2. Micro projectors etc.

All optical projectors, as defined, are fundamentally alike. They all display magnified image on an appropriate viewing screen, as an aid to more precise determination of dimension, form and occasionally physical characteristics of sample parts.

For precision measurements, the optical system must project images which are clear, sharp and dimensionally accurate. The mechanical design and function of the projector must also be compatible with the precision of the optical system.

Therefore, the following figure shows the basic working principle of optical system arrangement of all projectors. There are numerous arrangements of this simple system which sometimes give an air of refinement and fundamental difference to certain types of projector, but the method of optical image formation is always the same



They are four essential elements in a projection system. They are source of light, collimating or condensing lens, projection lens and screen. The illumination required practically for all engineering projectors is a parallel beam, and

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Carries a follower, which is projected by the light beam as it moves. This follower may be of three types.

a) Probe
b) Dot
c) Reticle.

The probe and dot followers are used when the size of the part is less than view field of the projector at the given magnification. The reticle guage follower is more versatile and is not restricted by part size or magnification

Essential elements of the optical System

The optical projector is a versatile instrument widely used in many phases of Quality Control and production and has become almost a necessity in the well-equipped toolroom. It has made possible the effective measurement of great numbers of Components. Because of size, material Composition, or dimensional Characteristics, posses Serious difficulties to other measurement methods.

The term "optical projector" here is used as a generic term to describe what have been variously called Contour projectors, optical Comparators, shadow graphs, lanterns micro-projectors, etc. No generally accepted nomenclature exists for this basic type of measuring equipment.

Optical projectors posses a Special Capability, that it is able to display a two-dimensional projection of a part rather than a single linear dimension as with most other gauging devices

Industrial use of optical projectors involves three basic elements. They are,

1. The projector itself
2. A Screen layout or chart-gauge for the Comparision or

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Important uses of Optical Projectors

The two basic applications or uses of optical projectors are as follows,

Firstly the use of a projector for So-Called tool room applications and single-piece inspection. Such a projector requires precision in the staging table mechanism and in the measuring devices associated with it. Since measurements are made with reference to a cross line on the center of th Projector Screen, just as in a tool maker's microScope, there is no prime requirement for a Completely accurate image over the entire Screen. A clear well defined image will Suffice.

Thus, for tool room applications prime emphasis is placed on mechanical measuring, while for Comparison application prime emphasis is placed on the accuracy of the optical System.

Chart gauges in Optical projectors

Chart gauges are of high important for the effective use of the optical projectors. point of reference for the Operator is provided by them. These are generally processed on glass or plastic. Chart gauges are of three types. They are as follows.

1. Replacement type
2. Over-Screen type
3. Overlay type.

1. Replacement type

The replacement chart gauges are used as a substitute for the standard viewing Screen of a projector. Therefore, it must have all the required physical characteristics like thickness, flatness, Surface, texture, etc., as of the original Screen.

It should be properly and correctly positioned, the lines marked on the ground Surface should face the operator

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5. A viewing Screen to receive the projected image.
6. Measuring devices were required

Aberrations

the Quality, Contrast and accuracy of an image produced by an optical projector are influenced by the aberrations in the optical System. these aberrations in optical elements make the light rays passing through them to deviate from the desired path, there by reducing the image quanlity, contrast and accuracy.

The most common aberrations found in an optical projector are as follows.

(a) Distortion

It results due to non-uniform magnification from Centre to edge of the Screen

(b) field Curvature

It is the out of focus from Center to edge due to Spherical shapes of the Screen.

(c) Chromatic Aberration

It is caused due to the dispersion of white light by optical System and inability to focus all the Colours Simultaneously in the plane of the Screen

(d) Lateral Color

It is caused by unequal magnification of blue and red Colour in the image. Distinct blue or red fringes appear at the edges of images

(e) The image Contrast is also influenced by viewing Screen mirriors and mechanical mounting of the optical element to reduce flare and stray light.

The aberrations Can be overcome by suitably selecting the light Source, distance at which the lens is placed from the light Source.

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If the path difference between reflected rays is even multiple of half wavelength they will be out of phase and of dark band. If the path difference is odd multiple of half wavelength there will be inphase with each other and will reinforce each other. So brightness will be observed. Alternate dark and bright bands as shown in figure. We will get depending upon the air gap and are due to interference of light.

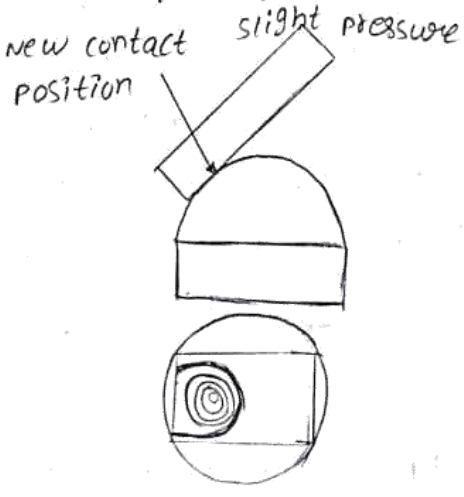
Contact is made at the central high point, resulting in a fringe pattern of concentric circles. If, now, each adjacent represents a change in elevation of the work surface relative to the optical flat of 1/2, then

$\frac{\lambda}{2} \times n$ = Total change in elevation from point of contact of the outermost fringe

Where,

λ = Wavelength of light used

n = Number of adjacent fringes observed.



Commonly, optical flats are used in normal daylight, the spectrum of which has a wavelength of approximately 0.5 mm. Thus, each fringe interval corresponds to a change in elevation of the surface of 0.25 mm.

Suppose an optical flat to be laid onto a surface and the resulting fringe pattern is that

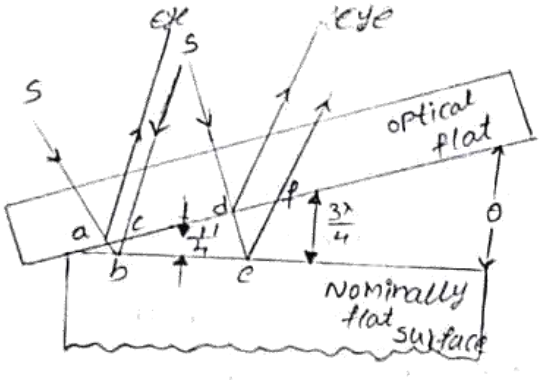
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Such surfaces are normally produced by grinding followed by successive lapping operations until a high degree of flatness combined with a high surface finish is achieved. Virtu-ally the use of light interference using an optical flat as a reference plane

Optical flats are used to check the flatness of work pieces, gauges blocks, micrometer anvils etc. They are cylindri-cal pieces, from 25 by 85 mm to 300 by 70 mm.

These are made of a clear material, such as fused quartz and have two faces perfectly parallel to each other which are accurate within a few millionth of a centimeter. Some optical flats have both the parallel faces ground and lapped, other are truly only on one side.

The principle of an optical flat is illustrated in figure (1). The optical flat is placed over the work piece to be checked so that a thin work piece interval in resting on a flat surface plate. refracted along AB through the flat A+B, a part of this light is reflected from the bottom face of the flat along BC and it leaves the flat at C.



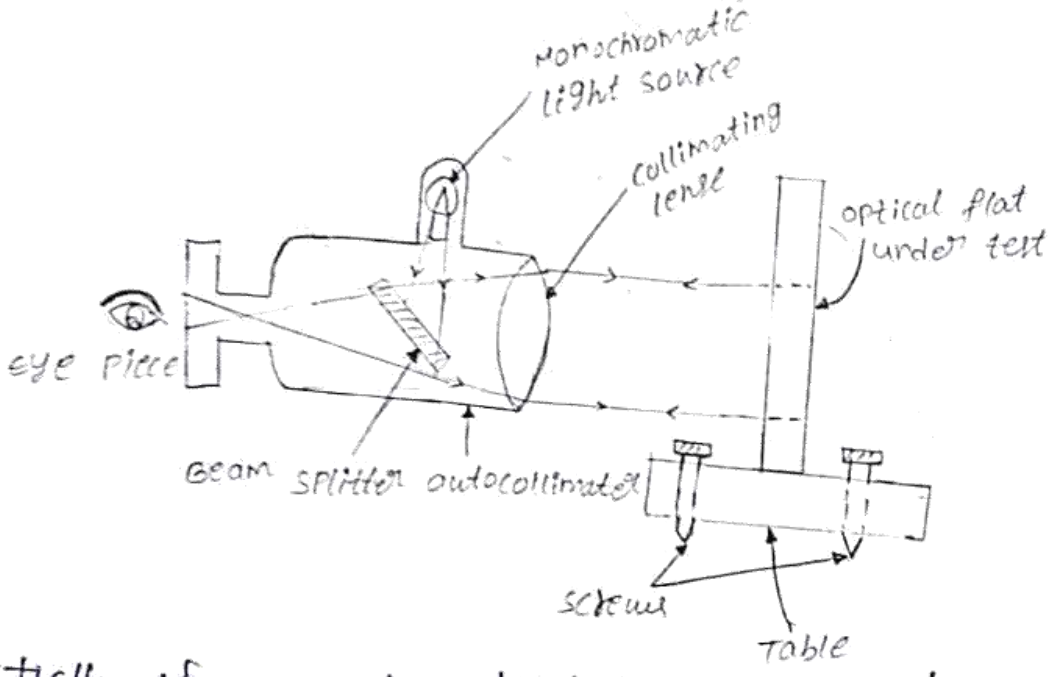
The second part of light travels an extra distance of (BD+DE) than the first part of light. Also, it is grown out of phase by π radius, which is reflecting from the work surface at D when light travelling in air along BD is reflected at the work surface, which is optically more dense than air, there

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there is a change in phase of π radians).

Parallelism Test by Using Optical flats

To test the parallelism of working surfaces of type B optical flats, fizeau interferometer method is used. The arrangement of fizeau interferometer method is modified and shown in the figure.



Initially, the monochromatic light source is focussed onto the passed provide in the eye-piece, where it gets partically reflected by a beam splitter. The reflected light then strikes to the collimating lense and it gets collimated. and deliver it to the optical flat which is being under test.

The optical parallelism of two flat surfaces is given by,

$$\frac{\delta}{2} \times \frac{1}{\mu} \text{ (microns}$$

where

$\frac{\delta}{2}$ - Different between the thickness of Flat

μ - Refractive index of material

δ - wavelength of light.

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flatness very accurately.

Advantages of Interferometers over Optical flats

1. The use of interferometer is faster and easier than that of optical flats.
2. With the use of interferometers high accuracies can be obtained.
3. Interferometers includes the refined arrangements which overcomes the disadvantages of optical flats.
4. With the use of interferometers, controlling of the lay of optical flat can be done.
5. Orientation of the fringes can be accomplished to the maximum advantages.

Interferometer

It is an optical instrument used for measuring flatness and determining the length of slip gauges by a suitable wave-length of light. It has a beam divider which detects the flatness very accurately.

Types of Interferometer

1. Michaleson interferometer
2. Multiple beam interferometer
3. Laser interferometer
4. Fabry - perot interferometer
5. fringe counting interferometer
6. NPL flatness interferometer
7. Pitter NPL gauge interferometer
8. Zeiss gauge block interferometer.

Working principle of Michaleson Interferometer.

This is the oldest type of interferometer, which has subsequently been modified in several respects and lot of

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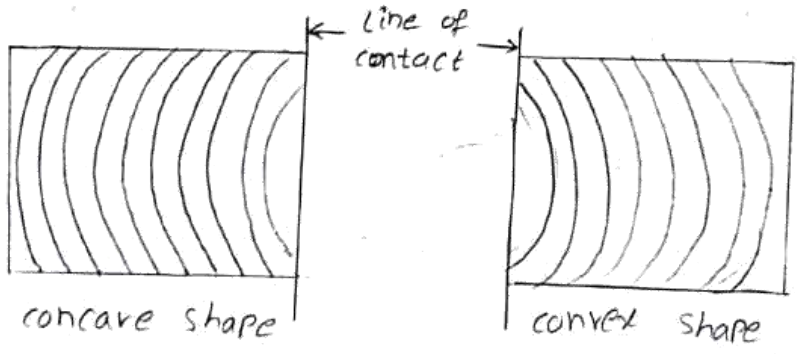
Whether the given surface is flat or curved.

The surface to be tested is placed with an optical flat, a monochromatic light is illuminated on the surface therefore, interference fringes are observed. The interference fringes are alternate bands and are formed by a thin layer of air, grasp between the bottom surface of an optical flat and top surface of test piece.

if the surface of test piece is not flat, then the fringe pattern of alternate bands are curve shaped and circular bands are observed at the point of contact with a central bright spot.

ii) whether the curved surface is convex or concave.

To find whether the surface is convex or concave shape, the surface of test piece is pressed with the finger at the edge tip. Thus, circular bands are disturbed and fringes gets closed, therefore the surface is convex shape.



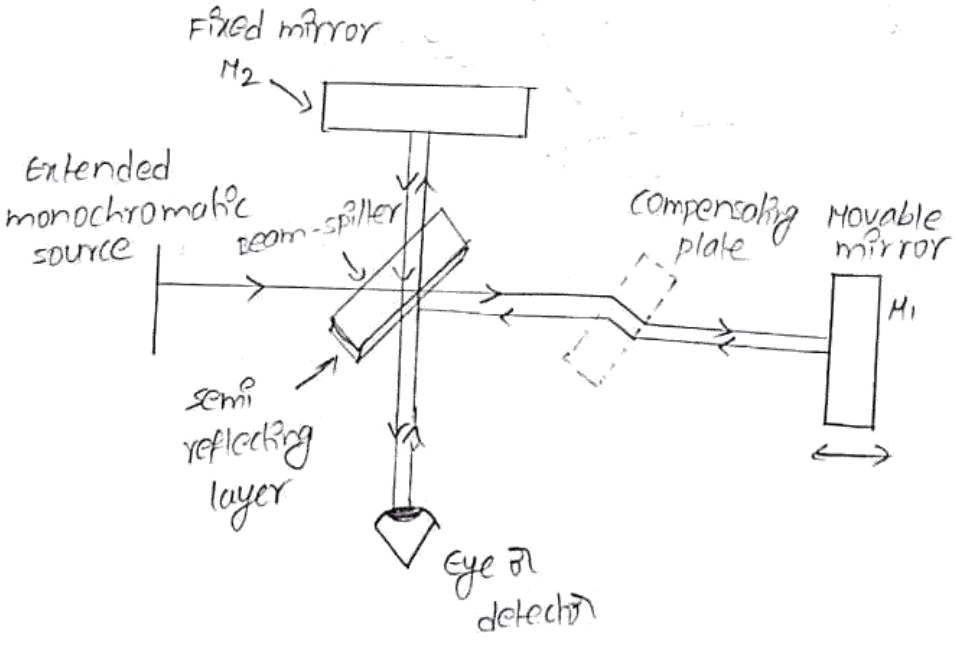
Interferometry - Interference of light - michaleson's interferometer, NPL flatness interferometer and NPL Gauge interferometer.

It is an optical instoument used for measuring flatness and determining the length of slip gauges by a suitable wave length flight. It has a beam divider which scatters the incoming ray into two parts. These scattered beam of rays are recombined in the same beam divider, which detects the

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Sophistication introduced

Michaleson interferometer utilizes monochromatic light from an extended source. The light falls on a beam splitter which splits the lights into two rays of equal intensity at right angles. One ray is transmitted to mirror M_1 and other is reflected through beam splitter to mirror M_2. From both these mirror, the rays are reflected back. The mirror M_2 is fixed and the reflected ray from M_1 serves as reference beam. Every half wavelength of mirror travel produces a change in the measured optical path of one wave length and the reflected beam from the moving mirror shifts through 360° phase change. When the reference beam reflected from the fixed mirror and the beam reflected from the moving mirror rejoin at the beam splitter, they alternately reinforce and cancel each other as the mirror moves. Thus each cycle of intensity at the eye represents $\lambda/2$ of the travel of mirror.



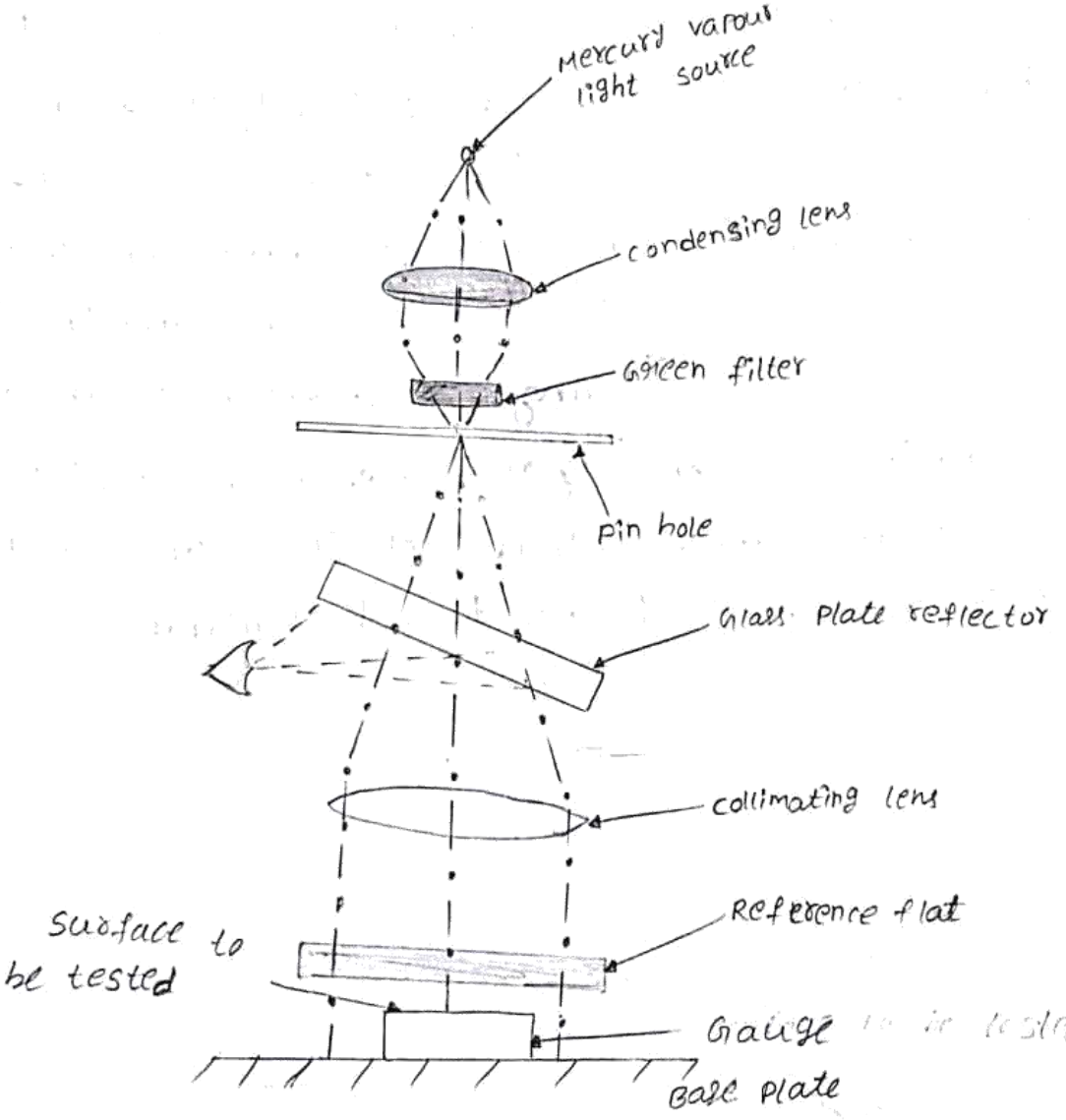
When monochromatic light is used to source, the fringes can be seen over a range of path difference that may vary

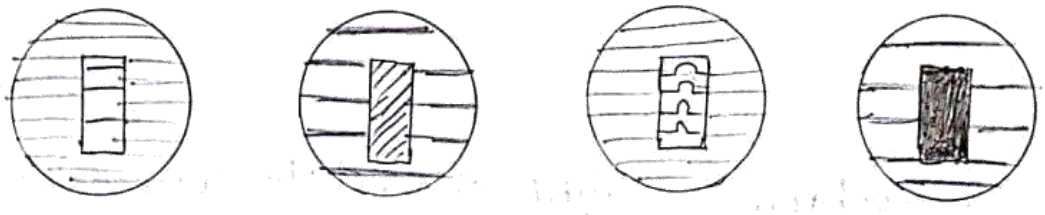
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from a few to a million wavelengths, depending on the source. The wavelength are not important, but only their differences affect fringe formation.

NPL flatness interferometer.

The instrument shown in diagrammatic form in figure (a) was designed by the National Physical Laboratory and is manufactured commercially by Converty Gauge and Tool CO. Ltd and Hilger and Watts Ltd.





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Optical Arrangement of Interferometer for Testing flatness of Surface

It consists essentially a mercury-vapour lamp whose radiations are passed through a green filter, thus removing all other colors and leaving a green monochromatic light whose wavelength is very close to 0.5mm. This light is focused onto a pinhole, giving an intense point source of monochromatic light, which is in the focal plane of a collimating lens and is thus projected as a parallel beam of light. This beam is directed onto the gauge to be tested through an optical flat so that interference fringes are formed across the face of the gauge, the fringes being viewed from directly above by means of a thick glass plate semi-reflector set at 45° to the optical axis.

An advantages of this instoument is that it can be also be used for testing the parallelism between gauge surfaces. Two methods are used,

a) for gauges lesser than 25mm in length.
b) for gauges greater than 25mm in length

If the gauge being tested is more than 25mm in length the fringe pattern on the base plate is difficult to observe but the base plate is rotary and its underside is lapped truly parallel with its working surface. Therefore, if a non parallel gauge is viewed the angle it makes with the optical will be as in figure.

Consider a gauge and is fringes in the second position. In figure(c), the distance between the gauge and the optical flat has increased by a distance δ_2.

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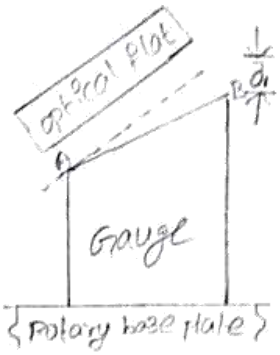


Fig (b)

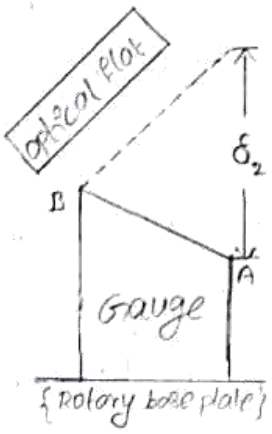


Fig (c)

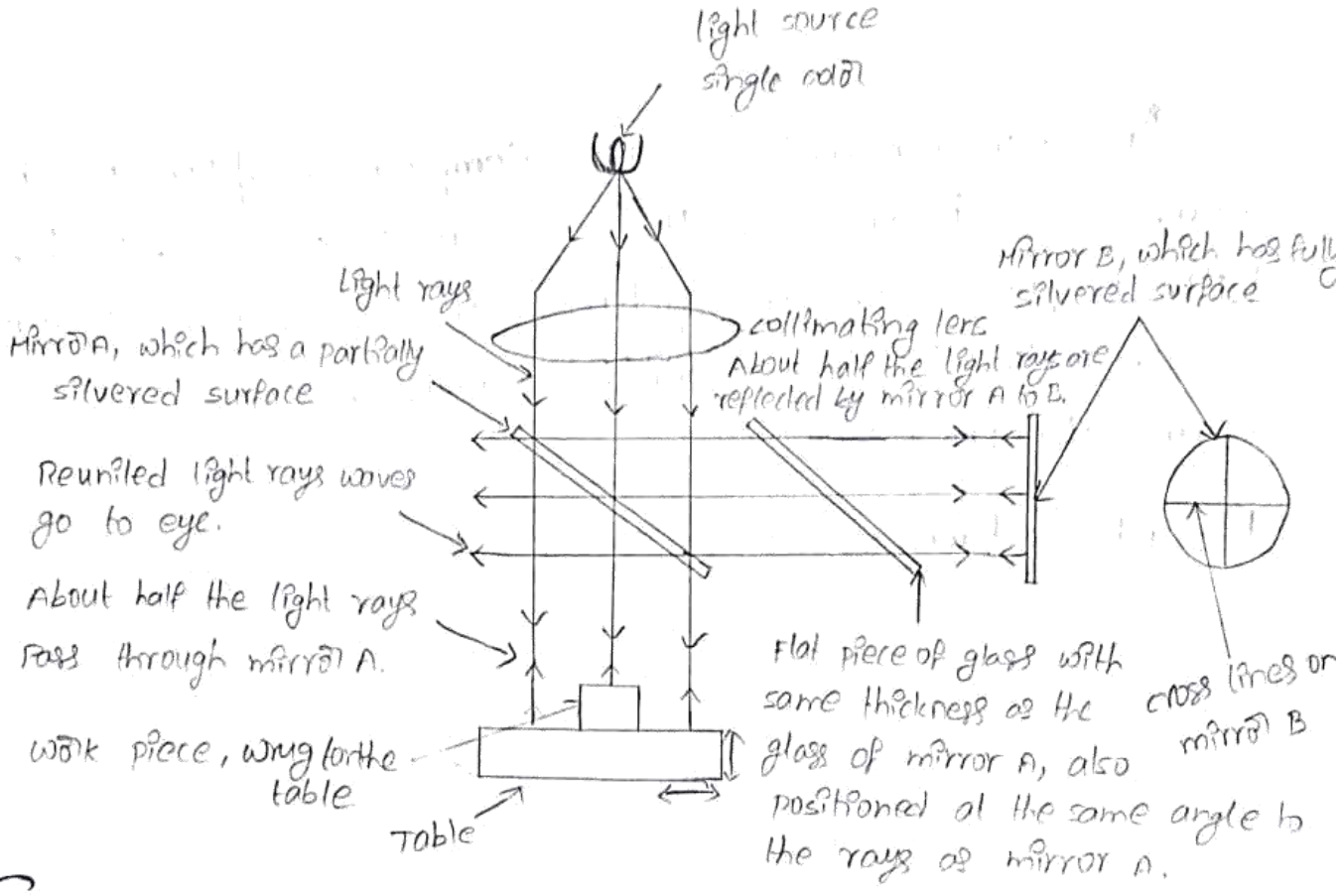
Interferometer.

An interferometer is a measuring instrument, which also makes use of light-wave interference. The use of interferometers is faster and easier than that of optical flats and they are considered to be the most accurate measuring instruments available to day. Different kinds of interferometer have been designed, employing slightly different methods to accomplish the same results. A typical interferometer, illustrating the basic principles which are employed, is shown in figure(1)

As shown in light ray from a single color light source are collimated into parallel ray by a lens. When these rays reach the partially silvered surface of mirror A,

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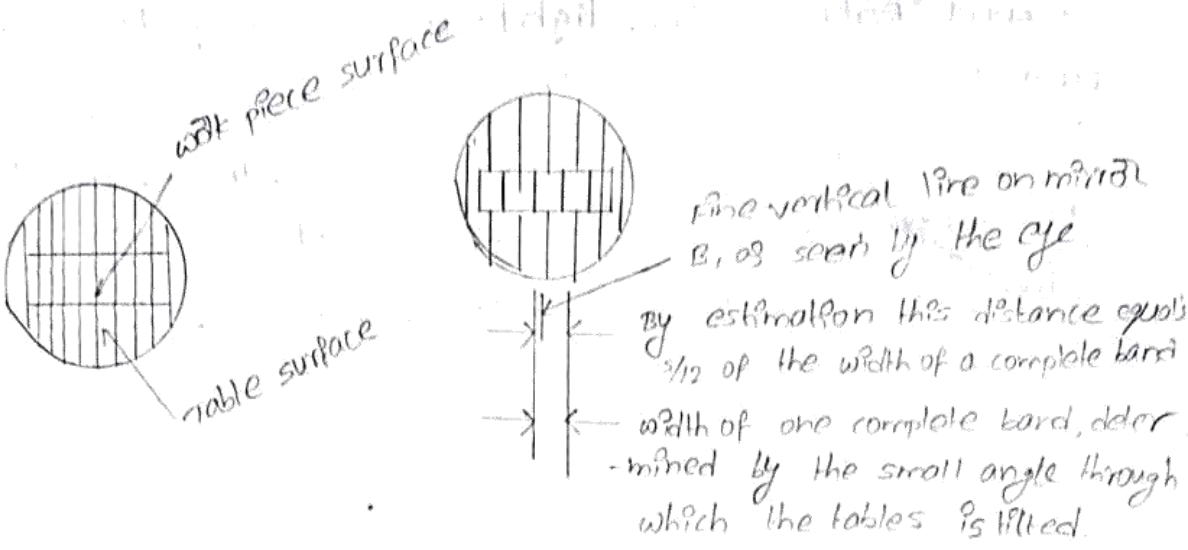
About half of the light is reflected towards mirror B and the other passes through the silvered surface towards the work piece and table surfaces. Thus, the light rays have been divided and directed along two different paths. These divided light rays are then reflected back to mirror A.



Since the bands are straight, parallel, and equally spaced, both surfaces are seen to be flat. In this example, a comparison is made between the height of the workpiece and the height above the table, within the range of a half wavelength. The measurement to the nearest number of half wavelengths should be previously determined by a less precise measurement method.

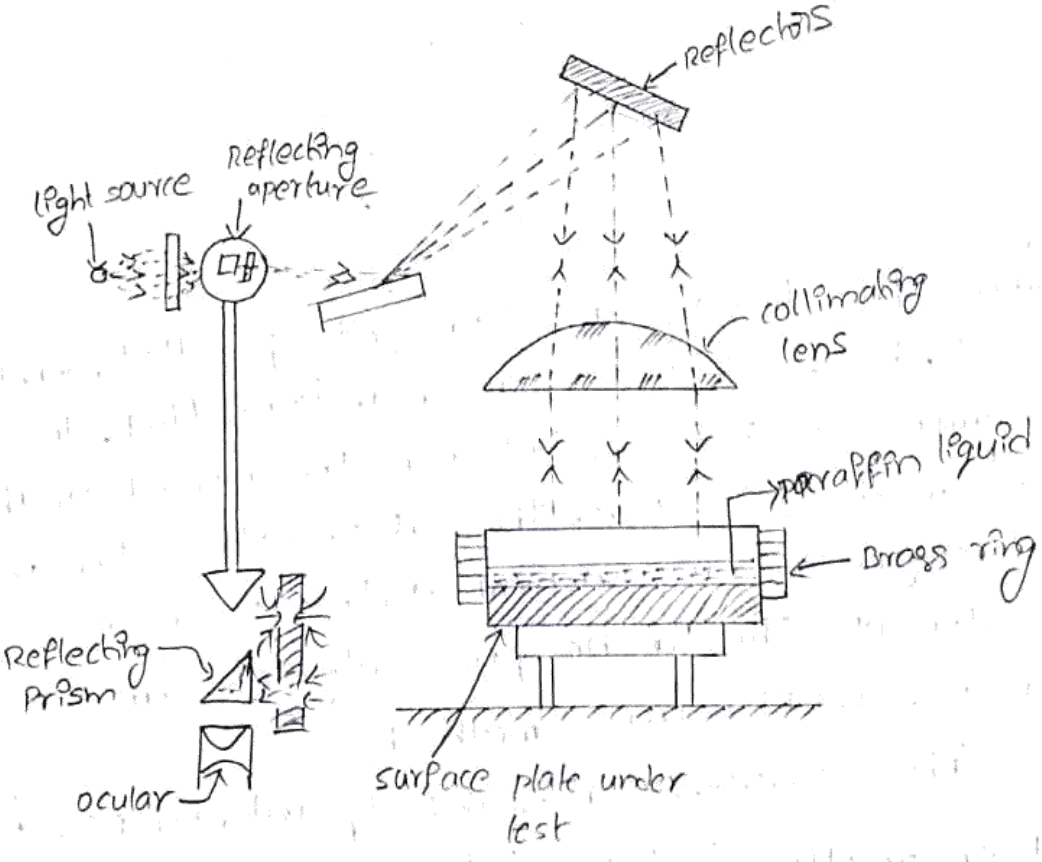
This causes a series of interference bands to appear on the surfaces of the work piece as shown in fig (a)

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Another example is the Comparision of the height of a worn gauge block with that of a master gauge block, where both heights are already known to be within a few millions of an inch. for this Comparison, both of the gauge blocks are wrung to the table.

liquid Surface interferometer.



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The apparatus consists of a monochromatic light source, reflecting aperture, reflectors, collimating lens, brass ring Paraffin liquid and the surface plate to be tested.

The given figure explains the testing of a surface plate The surface plate is surrounded by a brass ring, containing paraffin liquid upto a height of 10mm. The upper surface of this liquid acts as the first reflecting surface

If the surface plate is tilted with respect to the horizontal plane through a small angle interference takes place between the incident rays on the surface of the paraffin liquid and those refracted and then reflected at the surface plate. The reflected light returns back through another aperture to be delivered in a reflecting prism to the ocular through which the interference fringes can be observed.

Understand by Moire fringes

The name given to the patterns whose formation is generated by overlapping of two layers of fine fabrics is known as Moire fringes. These are observed when the index grating is rotating slightly in its own plane, instead of being kept parallel to the scale grating. In this case, the intersection of the lines of two grating are clearly visible as dark Moire fringes running at right angles to grating lines. If there is a transverse movement in the index position repeats itself after change of one grating period.

Moire fringes can be used for angular displacement by the use of radially ruled grating. Since one fringe pitch corresponds to a height change between optical flat and surface of one half-wave length.

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Therefore, angles of 1mm pitch = $\frac{\lambda}{2}$ radians = $\frac{1}{3982}$ radius

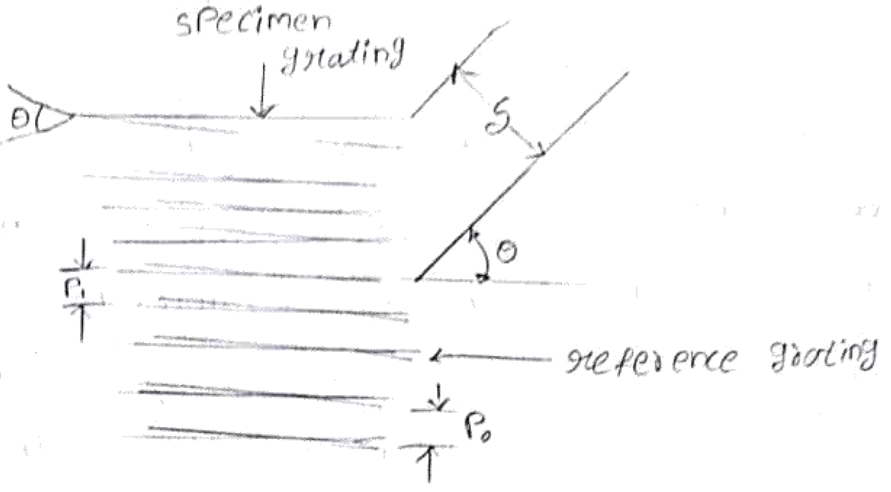


figure: The formation of Moire fringes

The above figure demonstrates the formation of a Moire fringes pattern.

Here

P_0 - The distance between the adjacent lines on the grating or specimen grating pitch

S - The distance between the adjacent Moire fringes.

P_1 - pitch of the Specimen grating

$$\therefore S = \frac{(P_0 \times P_1)}{[(P_0 \sin\theta)^2 + (P_0 \cos\theta - P_1)^2]^{1/2}}$$

where

θ - Angle between the two gratings.

In most practical situations gratings are aligned with θ close to 0.

$$\therefore S = \frac{P_0 P_1}{P_0 - P_1} \quad \text{--- (1)}$$

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$$\frac{1}{S} \cdot \frac{P_0 - P_1}{P_0 P_1} = \frac{1}{P_1} - \frac{1}{P_0}$$

Here, $\frac{1}{S}$ is called Spatial frequency.

Fundamental difference between the length and flatness interferometer.

The length interferometer measures the gauges length from a Specified point by first defining the wavelength. The measurement of length interferometer is regarded as the measurement of the wavelength of a Spectral line passed through the gauge and fringe pattern observed in the telescope.

The Flatness interferometer, measures the surface of a plate has undergone any irregularities or not. In testing flatness of a surface plate, the actual deviation from the true plane at various points is measured. The flatness interferometer detects the roughness of the surface and Confirms whether the surface is flat or not by observing the interference fringes observed by using monochromatic light source, the incident rays from which may be either diffused or parallel.

The fundamental difference between the length interferometer and flatness interferometer is that a constant deviation prism is incorporated in a latter which divides the light into a large number of parallel beams. The individual parallel beam having a different and closely defined wavelength of known value

Laser beam in interferometry

The following are the advantages of laser beam in interferometry.

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geometrical quality related to the perfect plane. (77)

For testing of flatness of surface plate, the general practice is to measure the actual deviation from true planes at different points. The various methods of flatness testing are,

1. Spirit level method
2. Beam Comparator
3. Auto Collimator
4. Laser beam
5. Interference method.

The symbol for flatness is '▱' in drawings flatness symbol is shown and tolerance is mentioned as, ▱ | 0.04

b) Straightness

A straight line may be defined as the shortest distance b/w two points on the plane. The normal distance between the two straight lines indicates the straightness of the plane. The basic principle about the straightness measurement is given by Bryan

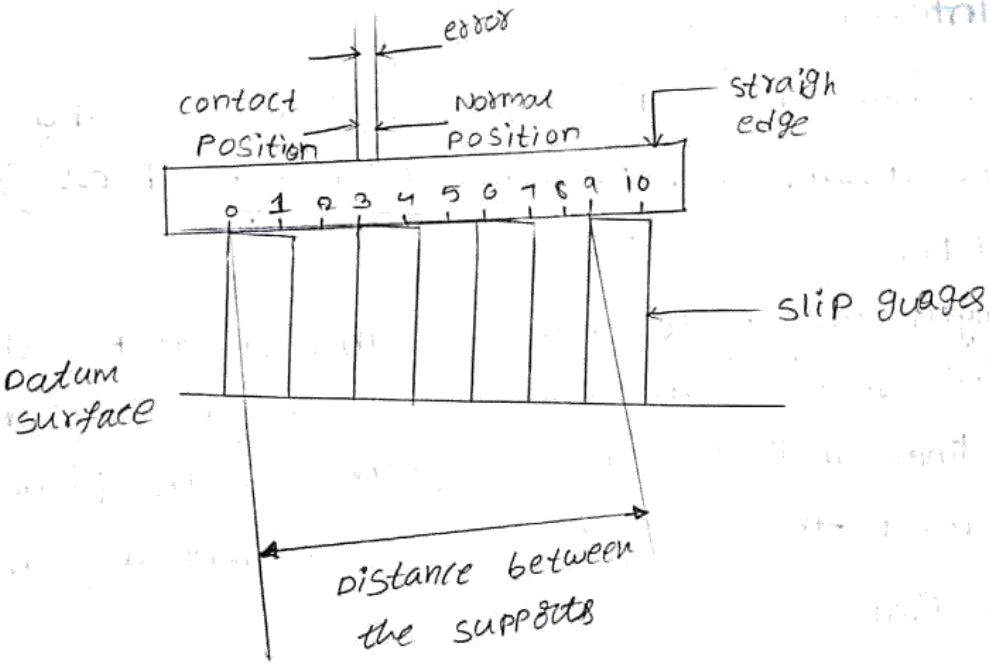
(c) optical flat.

Optical flats are cylindrical in shape and the working surfaces of the optical flat is flat. Optical surfaces are of two types. i) Type A ii) Type B. Type A optical flat has only one surface flat and type B has both are the surfaces flat. Type A optical flat is used for testing precision measuring surfaces of flats. whereas type B optical flats are used for testing measuring surface of micrometers. Optical flat gives precision and accuracy. in measurement of flatness.

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flatness measurement using straight edges.

Straight edge is a measuring instrument or tool used to check the straightness and flatness of the parts. The basic principle involved for measuring straightness by a straight edge is wedge method. In this method, the straight edge is placed on the slip gauges of different lengths, with a slight inclination to the surface to be checked as shown in the figure below.



The distance between the gauges is divided into equal number of parts and are marked on the straight edge. When datum surface and straight edge are perfectly in a straight position, then the gap at each point will vary uniformly. Straight edges with a single edge are mainly used for checking straightness. for checking the straightness of an element at a cylindrical or taper surface, the straight edge is applied along the full length of the surface and is held before a bright back ground. The

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Absence of light between the straight edge and work surface indicates the straightness of the element and vice versa.

Utility of straight edge and surface plate in laboratories.

1. Straight edge is a measuring instrument or tool used to check the straightness and flatness of the parts in laboratories.
2. It is made up of steel or cast iron and widely used for testing machine tool slide ways.
3. They are heavily ribbed and bow shaped to prevent distortion.
4. Straight edges with a single edge are mainly used for checking straightness.
5. for checking the straightness of an element of a cylindrical or taper surface, the straight edge is applied along the full length of the surface and is held before a bright background.
6. for checking flatness, single edge as well as three and four-edged straight edges may be used
7. It can be applied in different directions at different place on the surface to be tested.

Utility of surfaces plate in laboratories

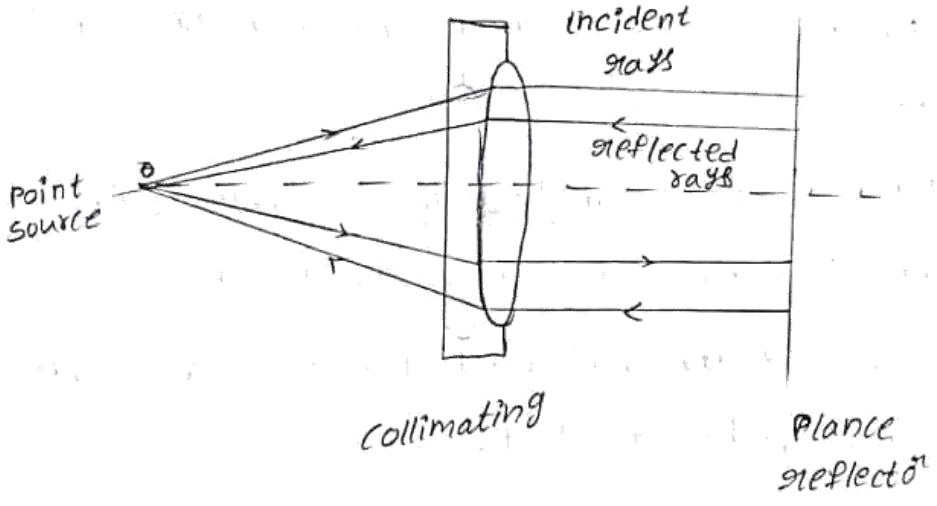
1. A surface plate or a plate has highly accurate flat surface.
2. It supplies a datum plane from which scribing measuring or comparing vertical distances can be done.

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3. For this the distance plane is used as reference surface for mounting comparators, optimeters, sine bars, slip gauge blocks, vernier height gauges and soon
4. The plate is usually a good quality casting, heavily ribbed for rigidity and with a thick top.
5. These are massive and highly rigid in design, due to which they carry their own weight as well as the weights of heavy objects placed on them.
6. An heat treatment process is done to relieve interval stress.

Autocollimator

Autocollimator is a type of optical instrument used to measure small angular inclinations. It is also used to check straightness, flatness and alignment of two plane surfaces or holes.



Working of principle

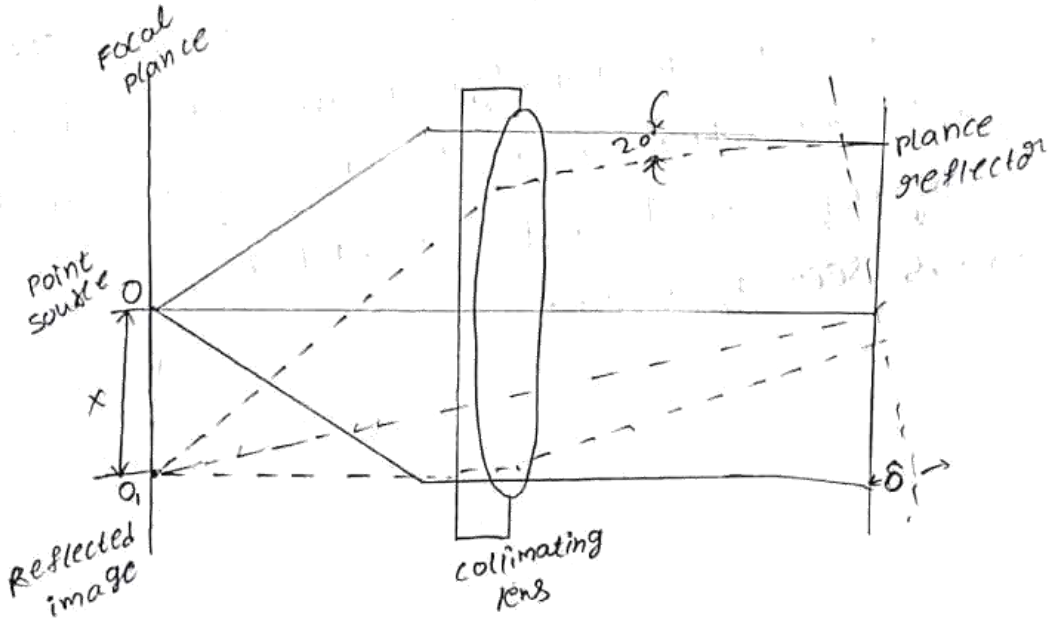
If a point source of light 'O' is placed at the principal focus of a collimation lens, it will be projected as a parallel beam of light. If this parallel beam now strikes

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A plane reflector which is normal to the optical axis, it will be reflected back along its own path and refocused at the source 'O' as shown in the following fig(1).

Point Sources of light in focal plane of a Collimating lens:

If the plane reflector is now tilted through some small angle 'θ', the reflected parallel beam will turn through '2θ' and will be throught to a focus at point 'O' in the focal plane at a distance 'x' from 'O' as shown in figure (2).



Autocollimator used for examination of plane surfaces.

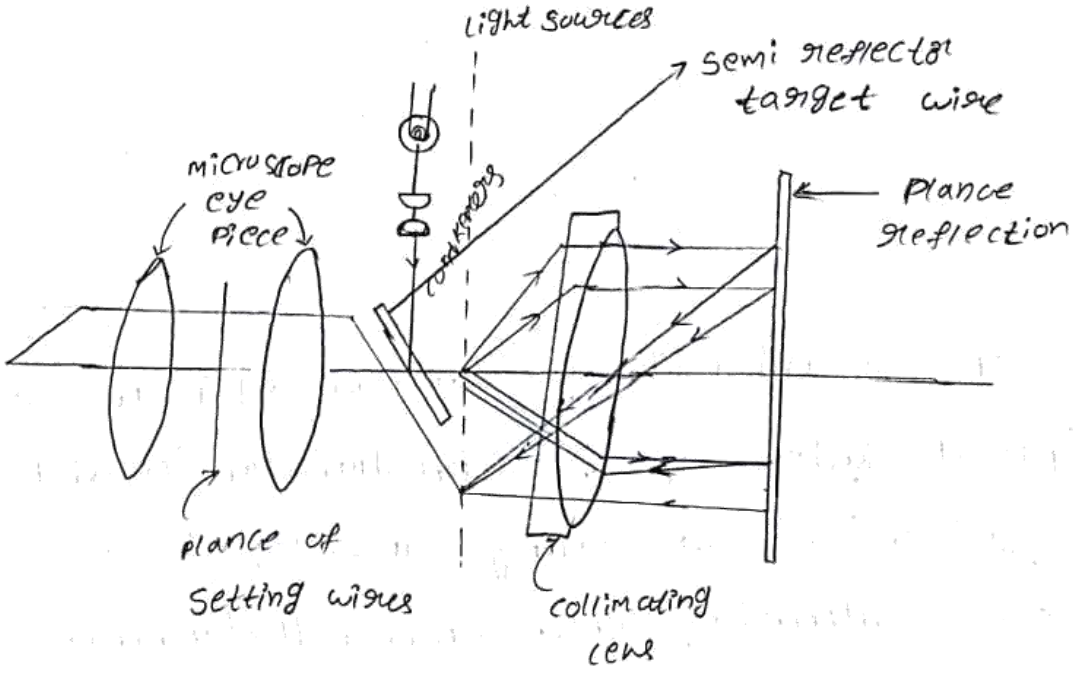
Optical system of an autocollimator consists of a pair of target wires and setting wires, light sources, plane reflector. Collimating lens. Semi-reflector, microscope unit etc. A pair of target wires are placed at same axis on the focal plane. when Collimating lens are illuminated

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at the back side of target wires, an images is projected which is staiked by the plane reflector. The projected image is brought to focal plane and can be viewed through microscope eye piece which is incorporated with scale and equipped with instruments. The scale can graduate 0.5 minute intervals.

In microscope unit, a pair of setting wires are placed which can be adjusted by micrometer.

The reading in micrometer is possible until the setting wires are extended on both sides of reflected images. The setting wires can move at 0.5 minutes per revolution by adjusting the micrometer drum and is divided into 60 equal parts. Thus, with the help of micrometer the value of reflector tilts 90° (i.e., right angle) can be found upto 0.5 second of core.



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Autocollimator

This instrument is used to measure small angular inclinations. It is used to check straightness, flatness and alignment as follows,

a) Examinations of plane Surfaces

An autocollimator is commonly used for checking the plane surfaces such as beds of machine tools. For this, a test block is made. The base of the block is flat with its working surface square, flat and polished to form a reflecting surface. The test block is placed at one end of the surface to be checked with its reflecting surface normal to the collimator axis which is mounted on a rigid stand. The collimator is adjusted until the cross wire and its image coincide as seen through the eyepiece

(b) Checking Secureness of Two Surfaces.

Suppose there are two machined surfaces at right angle to each other. Their squareness can be checked with the help of autocollimator to a high degree of accuracy in the same manner as explained above. The test block is first placed on the horizontal surface with its reflecting surface normal to the optical axis of the collimator and reading in the micrometer noted.

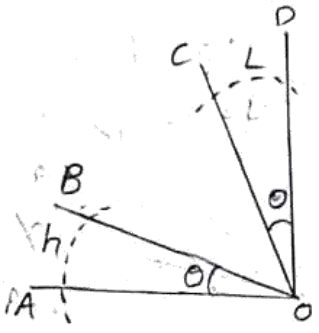
(c) Checking Alignment or Parallelism

Parallelism or alignment of two holes in a part can also be tested by the autocollimator in this case, a test bar will be placed alternately in each hole and Collimator reading is taken.

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2. Spirit level

The spirit level Comprises a sealed glass tube with is mounted on the base, a scale engraved on the top of this glass tube and a liquid filled in the tube. The inner surface of the tube is ground to a Convex barrel shape that has a larger radius. The precision level is Solely dependent upon the accuracy of the radius of tube If the spirit level is placed on a horizontal surface, then the bubble rests at the centre of the scale. Whenever the level i.e. OA and OB and Corresponding positions of the bubble C and D respectively



Consider

θ = Small angle through which the base is tilted

l = Distance travelled by the bubble.

h = Difference in heights between the ends of the base

L = Base length

R = Radius of curvature of the tube,

Then,

$$l = R\theta$$

Also $h \perp L\theta \Rightarrow \theta = \frac{h}{L}$

from equations (1) and (2) we get

$$l = \boxed{h\frac{R}{L}}$$

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States the uses of

(26)

1. Uses of Tool Makers flat

a) In the measurement of work of the highest preision, tool. makers flats are Used

b) It is used in inspecting of Small Components with precision gauge blocks.

ii Uses of Angle plate

a) Angle plate is a work holding device which is used as finture in metal working

b) As these plates posses excellent finishing and flat ness they can be used along with granite surface plate accuracies

c) with the help of angle plate, work can be clamped or held in a vertical position

d) In workshops or inspection laboratories the cast iron angle plates are used with surface plates for the purpose of measurement.

iiii Uses of V- Block.

a) In workshop and inspection puopose v-block are used widely for checking the roundness of cylindrical work-pieces.

b) These are also used for holding the cyclindrical workpiece for accurate centre marking.

c) for supporting rectangular components at 45° to the datum surface, v-blocks are employed.

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