FACULTY OF ENGINEERING

DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

MEASURING INSTRUMENTS

3 rd Year Production

Report On:

(10)

Abbe Measuring Machines

Metrology laboratory

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Class No:	***Signature***
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ABBE MEASURING MACHINES

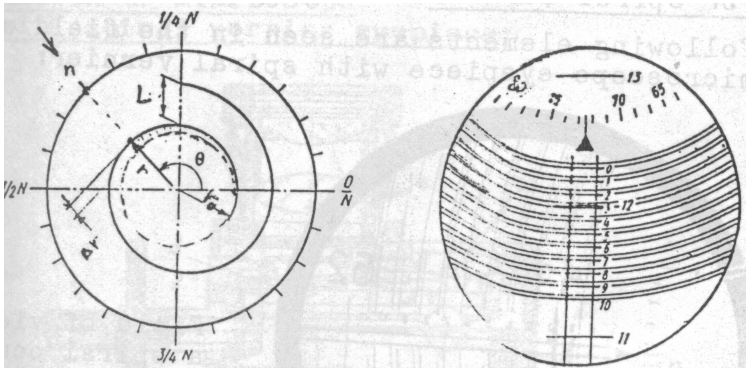
Introduction

Abbe metroscopes are measuring machines for universal use in the field of metrology. They have a compact construction (column or bed) and contain their own standards of measurement in form of scales.

Abbe metroscopes are designed for absolute and comparative measurement of lengths.

Principle of Spiral Vernier

The spiral vernier principle is based on the use of the Archimedean Spiral as shown below.



The equation of the spiral can be expressed as:

$$r = r_o + \Delta r$$

or

$$r = r_o + L \,.\, (\theta/360)$$

Where:

r_o = initial radius of spiral;

L = lead of spiral;

θ = angle of spiral turn.

The same equation can be presented in another form as follows:

$$\Delta r = L \cdot (n/N) = n \cdot S_v$$

where:

N = number of divisions into which circular scale is divided (usually 100 divisions);

n = angle of spiral turn expressed in divisions

$$S_v = L/N$$

Spiral vernier are usually built into microscope eyepieces, and a magnified image of a scale section is projected on them. In this manner, the parallax error is excluded and reading accuracy is increased.

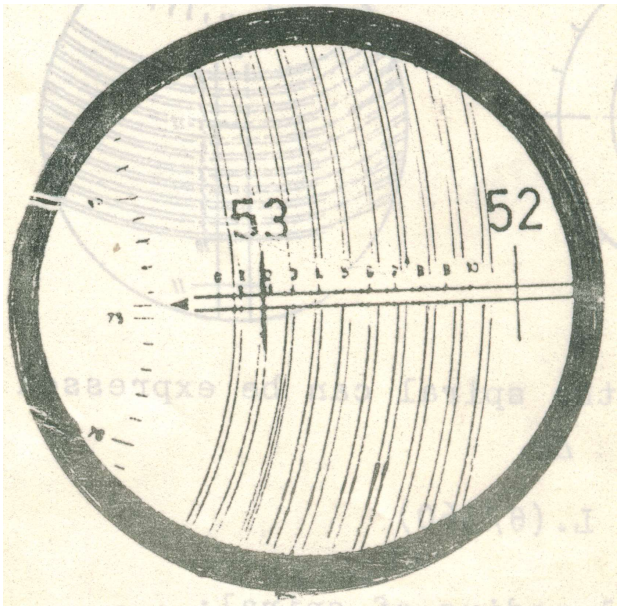
With the objective magnification being (M) and the scale divisions (spacing) of the main scale (S_m); the lead of the vernier spiral is determined by the formula;

$$L = (S_m \cdot M)\, m$$

Where (m) is the number of spiral turns within one scale division (spacing) magnified by the microscope (usually m = 10).

Reading of Spiral Vernier

The following elements are seen in the field of view, for a microscope eyepiece with spiral vernier:



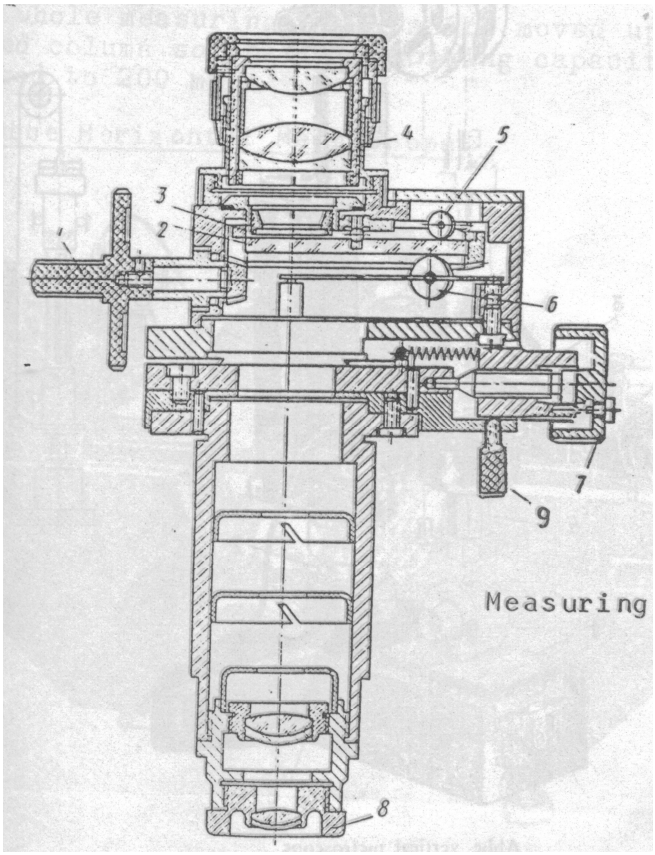
The image of the main scale millimeter graduations (scale marks 52 and 53), the eyepiece stationary linear scale having 10 graduations with a scale division of 0.01 mm (scale marks from 0 to 10), these scale marks being lined along the double radial line which end with an index; a section of the turning vernier circular scale graduated from 0 to 100 with a scale value of 0.001 mm; and a section of a double Archimedean spiral marked on the same gratitude as the circular scale.

The reading is taken as follow:

Whole millimeters are read as indicated by the scale mark of the main scale which is within the eyepiece stationary scale (53 mm). Tenths (1/10) of millimeter are read from the stationary scale in respect to the scale mark of the main scale (1/10 = 0.1 mm). Hundredths (1/100) and thousandths (1/1000) of millimeter are read from the vernier circular scale after the later is turned so as to put the scale mark of the main scale inside a double line of the spiral (0.075 mm).

The total reading value is determined by the sum of the three readings and is here equal to (53 + 0.1 + 0.065) = 53.175 mm.

Construction of microscope with spiral vernier eyepiece: gratitude 3. The double spiral and the circular scale gratitude 2. gratitude 2 is rotated with the aid of head (knob) 1 through bevel gear. A steel ball serves as a turning support for gratitude 2. this gratitude is pressed to adjustable rollers from below by means of two spring-loaded rollers 6.



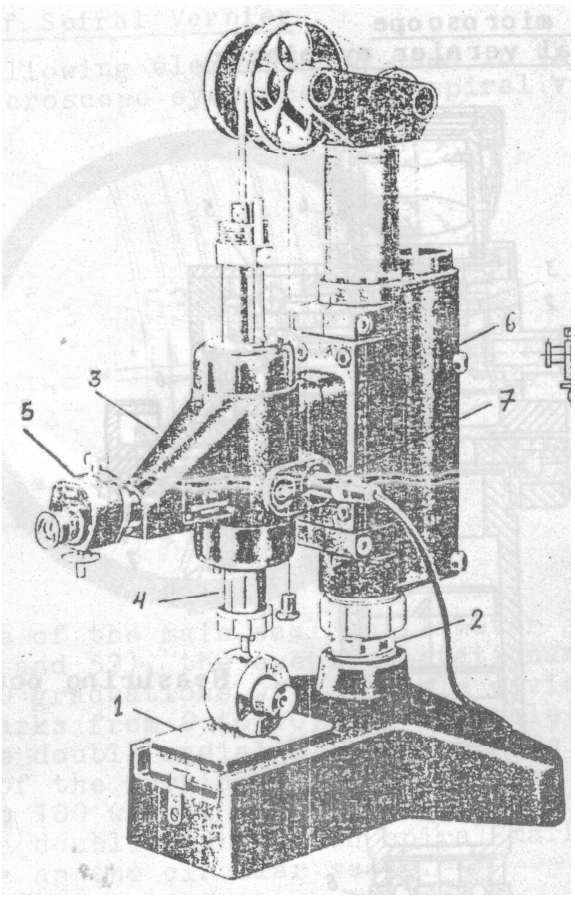
Setting the device to zero:

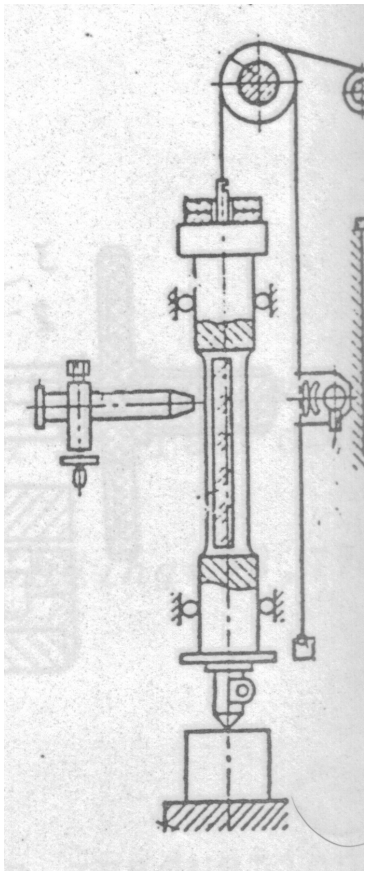
To set the device to zero, the eyepiece together with the vernier can be transversely displaced by means of screw 7. The adjusted position can be fixed by means of a lock 9.

Types of Abbe measuring machines:

I . Abbe Vertical Metroscope:

This machine can be used for direct measurement as well as for comparison. It consists of heavy base on which the measuring stage (1) is fixed. The stage provides the fixed measuring plane and on it exchangeable anvils can be mounted. A threaded column (2) is screwed in the base to carry the measuring head which consists of a bracket (3) and a dash-pot (6). The measuring spindle (4) slides vertically without friction in the bracket and it incorporates a 100 mm glass scale that can be observed through an Archimedean double spiral ocular (5) having a scale value of 0.001 mm. the measuring spindle can be fixed to the bracket by means of the clamp (7) and at can be fitted with exchangeable anvils. To counteract the weight of the measuring spindle, a steel band is provided to carry the spindle by one end and the other end is fixed to the piston of the dash-pot (6). The steel band moves with the spindle over two friction-less pulleys while the dash-pot controls the speed and the measuring force of the spindle.



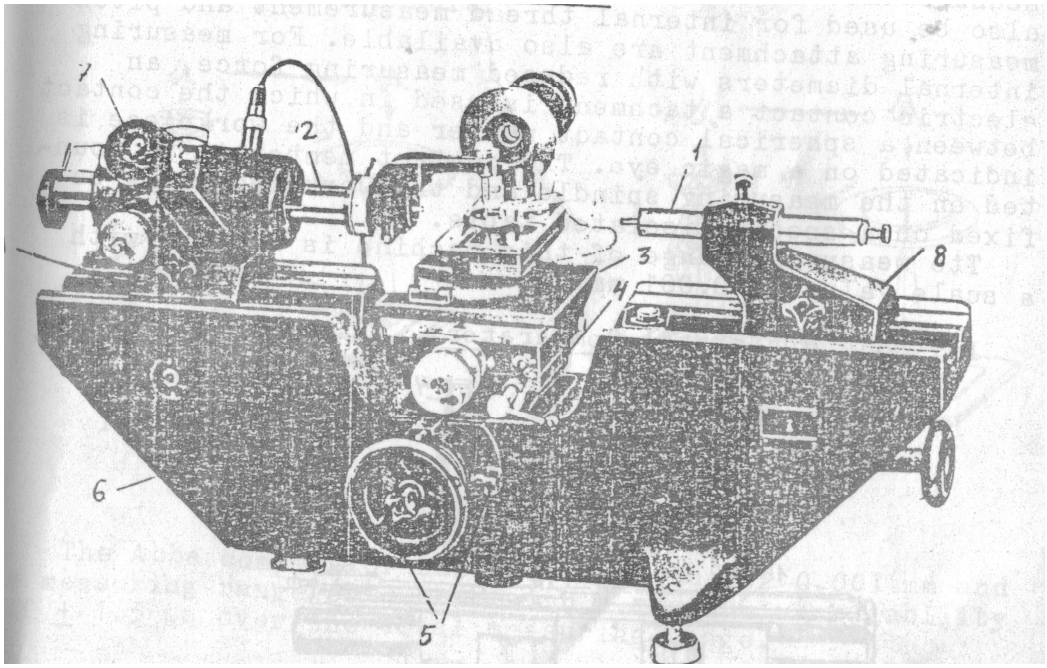


The whole measuring head can be moved upwards on the threaded column so that the working capacity can be increased to 200 mm.

II . Abbe Horizontal Metroscope:

This machine consists of a measuring head (2) similar to that of the vertical metroscope. The head is fixed horizontally on the left-hand side of a heavy bed (6). On the same level of the right-hand side a tailstock (8) is mounted in which a pinion (1) is fixed. This pinion can be fitted with exchangeable anvils that provide the fixed

measuring reference and it can be moved axially for the adjustment of the initial reading of the metroscope. Between the measuring head and the tailstock, a measuring stage (4) is provided whose height can be adjusted by means of a graduated wheel. Two stops (5) are used to prevent the stage from exceeding the highest and lowest positions required. The stage (4) can be tilted at small angles to ensure the correct position of the work piece with respect to the measuring axis. It can be moved in a cross-direction perpendicular to the measuring axis by actuating an ordinary micrometer.



Different attachments can be fixed on the stage for the purpose of mounting the work piece such as that used for mounting the cylindrical parts between two centers either parallel or perpendicular to the measuring axis.

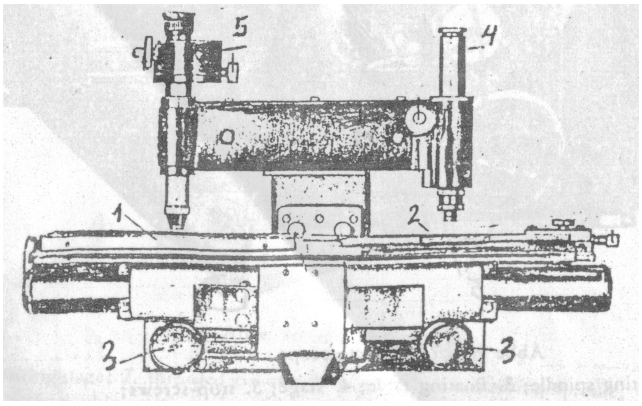
Also a floating table (3) can be used for two-point measurement. An internal measuring attachment that can also be used for internal thread measurement and pitch measuring attachment are also available. For measuring internal diameters with reduced measuring force, an electric contact attachment is used in which the contact between a spherical contact member and the work piece is indicated on a magic eye. The contact member is mounted on the measuring spindle and the work piece must be fixed on a special isolated table.

It measuring range of this machine is 200 mm, with a scale value of 0.001 mm.

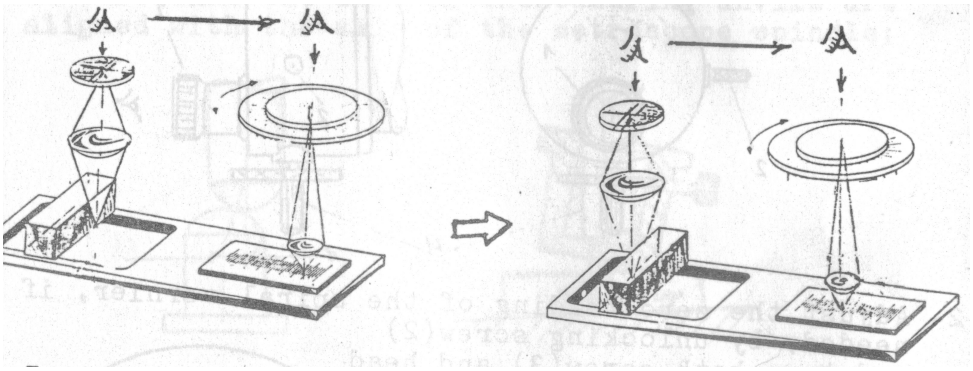
III . Abbe Horizontal Comparator:

This comparator provides the possibility of the direct comparison of the dimension required with a glass scale. Object and scale are mounted at the same level in line one behind the other on a common stage. The comparator consists of a stage on which the glass scale (1) and the object (2) are mounted. Above the object there is the adjusting microscope (4) and above the scale a measuring microscope with a double spiral ocular (5) is fixed. Both microscopes are rigidly mounted on the base but they can be tilted, together with the measuring stage at any angle up to 45^{o}. The inclined position provides a convenient oblique direction of view. The glass scale and the object are illuminated by any external source of light reflected on wok adjustable mirrors (3).

After adjusting the object below the adjusting microscope (4), an initial reading of the measuring microscope (5) is observed.



The stage must then be moved below the microscopes until the Final position of the object is achieved and adjusted by the adjusting microscope. In this position, the stage must be locked and the final reading of the measuring microscope is to be read. The difference between the initial and final readings gives the required result.

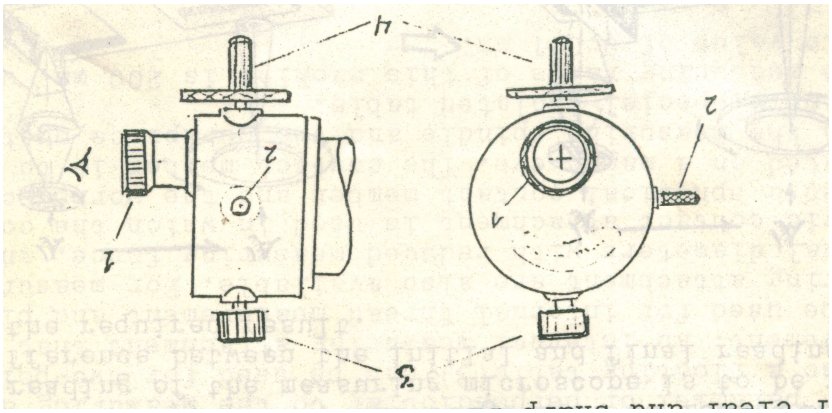


The Abbe comparator has a scale value of 0.001 mm and a measuring range of 200 mm with a maximum unreliability of ± 1.5 μm over the total measuring range.

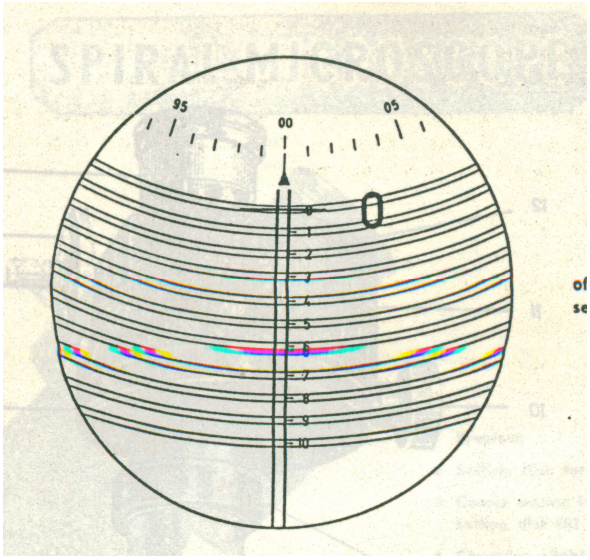
Precautions:

The following are some measuring precautions should be taking into consideration to improve the accuracy of measurement using Abbe metroscopes:

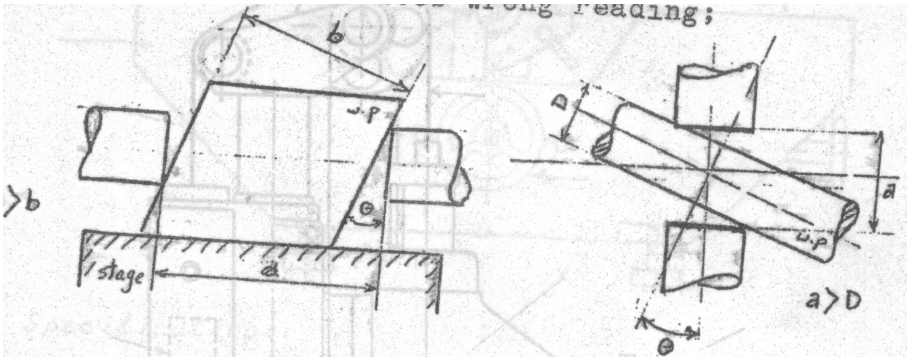
1. Adjust the microscope eyepiece, by turning head (1), for clear and sharp field of view;



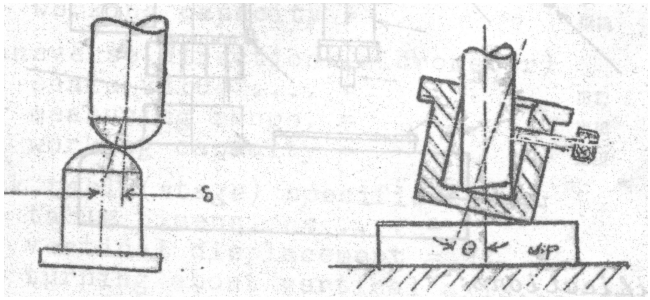
2. Adjust the zero reading of the spiral vernier, if needed, by unlocking screw (2) and turn both screw (3) and head (4) until zero reading is obtained, i.e. the field of view is similar to that shown in the figure.



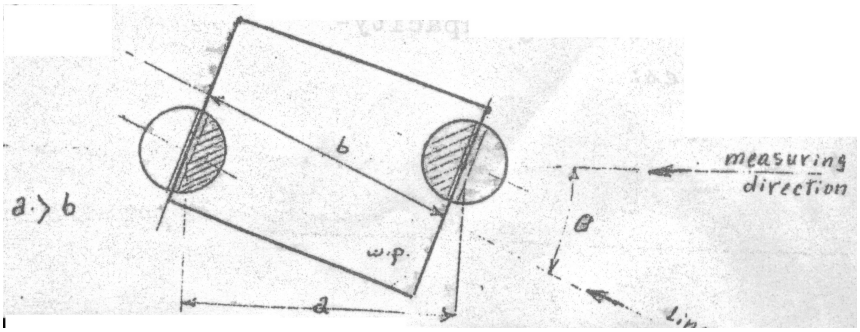
3. Avoid touching the measuring spindle or any sliding elements;
4. avoid touching measuring surfaces with bare hands; it has to be noted that: to release the measuring spindle for measurement; the spindle clamp screw is to be unlocked, as well as the stopping screw;
5. Check to see that the counter weight of the Abbe vertical and the Abbe horizontal metroscopes draws the measuring spindle to the end any time the spindle is released;
6. Be sure that the axis of the measuring spindle is aligned to the direction of measurement; otherwise the metroscope indicates wrong reading;
7. Be sure that the axis of the measuring anvils are aligned with the axis of the metroscope spindle;



8. With Abbe horizontal comparator, be sure that the line of measurement is aligned to the measuring direction.



9. With Abbe horizontal comparator, be sure that the line of measurement is aligned to the measuring direction.



THE EXPERIMENT

Main Objective:

To study the construction, specifications and uses of different types of Abbe measuring machines.

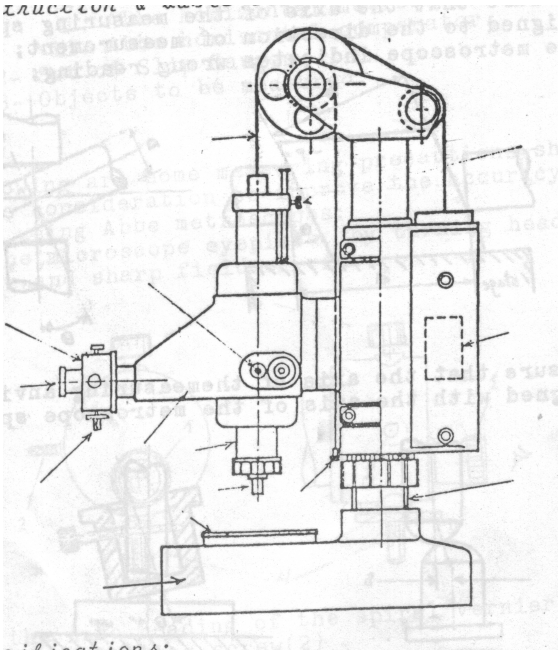
Apparatus:

1. Different types of Abbe measuring machines:
    i. Abbe vertical metroscope;
    ii. Abbe horizontal metroscope;
    iii. Abbe horizontal comparator.
2. Set of Slip Gauges.
3. Objects to be measured.

Objective

Study the construction and the specification of the Abbe Vertical Metroscope

1- Construction & Basic Elements



2- Specifications

Scale Value:

Measuring Range

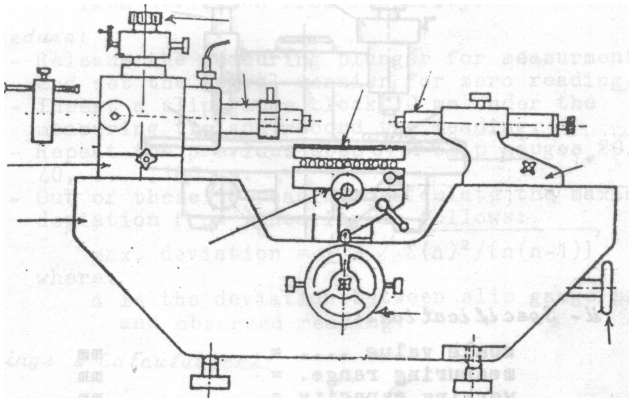
Working capacity

Uses

Objective

Study the construction and the specification of the Abbe Horizontal Metroscope

1- Construction & Basic Elements



2- Specifications

Axial direction (measuring spindle)

Scale Value:

Measuring Range

Working capacity

Transverse direction (micrometer)

Scale Value:

Measuring Range

Working capacity

Work table (stage)

Table dimension

Vertical displacement

Turning about vertical axis

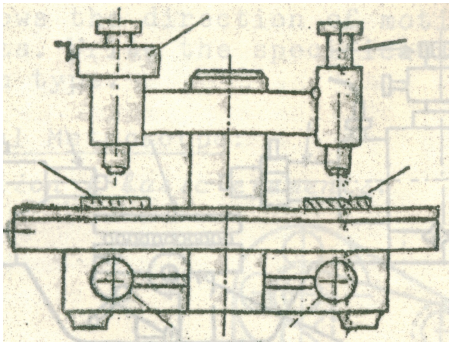
Turning about transverse

Uses

Objective

Study the construction and the specification of the Abbe Vertical Metroscope

1- Construction & Basic Elements



2- Specifications

Scale Value:

Measuring Range

Working capacity

Tilting angle of stage

Max dimensions of W.P

Uses

Main Objective:

Check the linearity of the scale graduation of the Abbe vertical metroscope using slip gauges. Plot the deviation of readings w. r. t. the slip gauge size. Calculate the maximum deviation from linearity.

Precautions:

- Release the measuring plunger for measurement and set the spiral vernier for zero reading.
- Insert a slip gauge block 10 mm under the measuring tip and record the reading.
- Repeat the previous step over slip gauges 20, 30, 40, …, 100 mm.
- Out of these 10 reading; calculate the maximum deviation from linearity as follows:

  Max. deviation = $\pm 3\sqrt{\sum(\Delta)^2 / \{n(n-1)\}}$

  Where:

  Δ is the deviation between slip gauge size and observed reading.

Readings & Calculations:

No.	S.G. size	Reading	(Δ) μm	$(\Delta)^2$
1	10 mm			
2	20 mm			
3	30 mm			
4	40 mm			
5	50 mm			
6	60 mm			
7	70 mm			
8	80 mm			
9	90 mm			
10	100 mm			
			$\sum(\Delta)^2 =$	

Results:

Max. deviation = $\pm 3\sqrt{\sum(\Delta)^2 / \{n(n-1)\}}$

= μm

Discussion

Objective

Measure the outer dimensions of the given part using the Abbe vertical metroscope

Sketch of the Part

Readings

Dimension	Readings			Average
	1	2	3	

Objective

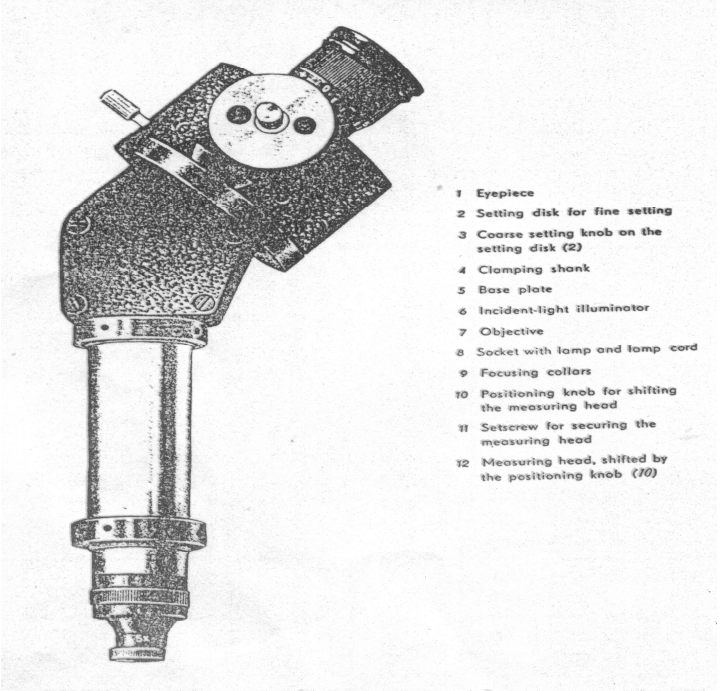
Measure the outer diameter of the given ball bearing using the different types of Abbe measuring using different types of Abbe measuring machines, and compare the obtained results. Discuss the different of results if existed.

Readings

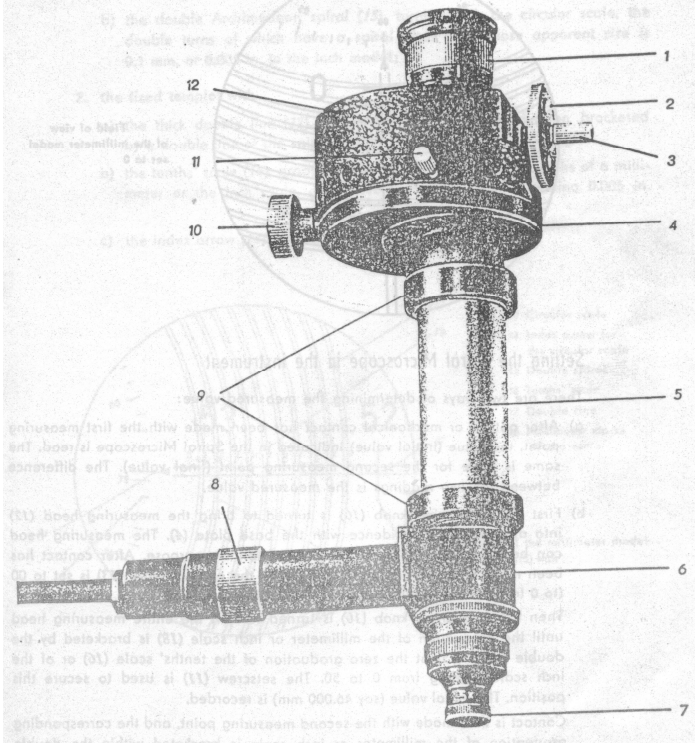
Type	Readings			Average
	1	2	3	
Vertical				
Horizontal				
Comparator				

Discussion & Conclusion

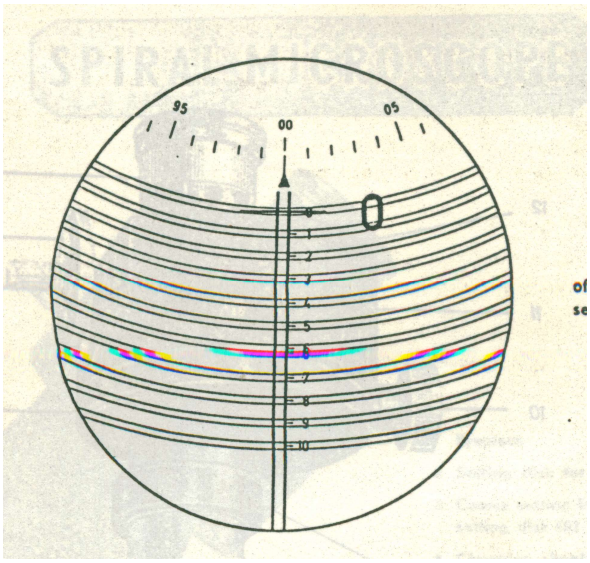
APPENDIX



1 Eyepiece
2 Setting disk for fine setting
3 Coarse setting knob on the setting disk (2)
4 Clamping shank
5 Base plate
6 Incident-light illuminator
7 Objective
8 Socket with lamp and lamp cord
9 Focusing collars
10 Positioning knob for shifting the measuring head
11 Setscrew for securing the measuring head
12 Measuring head, shifted by the positioning knob (10)



Setting the Spiral Microscope in the Instrument



There are two ways of determining the measured value:

(a) After optical or mechanical contact has been made with the first measuring point, the value (initial value) indicated in the Spiral Microscope is read. The same is done for the second measuring point (final value). The difference between the two readings is the measured value.

(b) First the positioning sob (10) is turned to bring the measuring head (12) into approximate coincidence with the base plate (4). The measuring head can be moved about 1 mm (or 0.05 in.) for this purpose. After contact has been made with the first measuring point, the circular scale (13) is set to 00 (to 0 in the inch model) by turning the setting disk (2).

Then the positioning knob (10) is turned to shift the entire measuring head until the graduation of the millimeter or inch scale (18) is bracketed by the double spiral (15) at the zero graduation of the tenths scale (16) or of the inch scale reading from 0 to 50. The setscrew (11) is used to secure this position. The initial value (say 45.000 mm) is recorded.

Contact is then made with the second measuring point, and the corresponding graduation of the millimeter or inch scale is bracketed within the double spiral by turning the coarse setting knot (3) or the setting disc. After the values have been read off, the lower number is subtracted from the higher one; the result is the measured value.

The determination of the measured value described under b) above is generally preferred, because this enables computation to be done in round figures. The sequence of readings is given in detail on page 8. There are two templates in the Spiral Microscope eyepiece:

1. The rotatable template, axis of which is outside the field of view, with:

    a) The hundredths' circular scale (13) to indicate hundredths and thousandths of a millimeter, or indicate thousandths and ten-thousandths of on inch in the model with the circular scale divided into 50 parts;

b) The double Archimedean spiral (15), turning with the circular scale, the double turns of which have a spiral pitch and whose apparent size is 0.1 mm, or 0.005 in. in the inch model;

2. The fixed template with:

a) The thick double line (17), within which the scale graduation bracketed by a double line of the spiral (15) is read;

b) The tenths' scale (16), graduated from 0 to 10, for reading tenths of a millimeter or the inch scale, graduated from 0 to 50, for reading 0.005 in.

c) The index arrow (15) for the circular scale.