FACULTY OF ENGINEERING
DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

MEASURING INSTRUMENTS
3 rd Year Production

Report On:

(4)

Micrometers

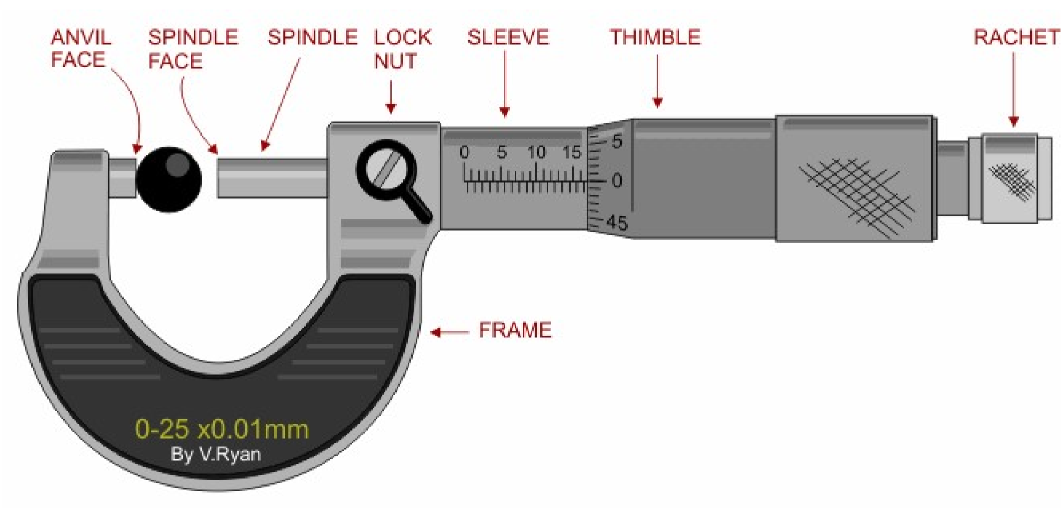
Metrology laboratory

Student Name	Remark
Class No:	Signature
B.N.	

2008/2009

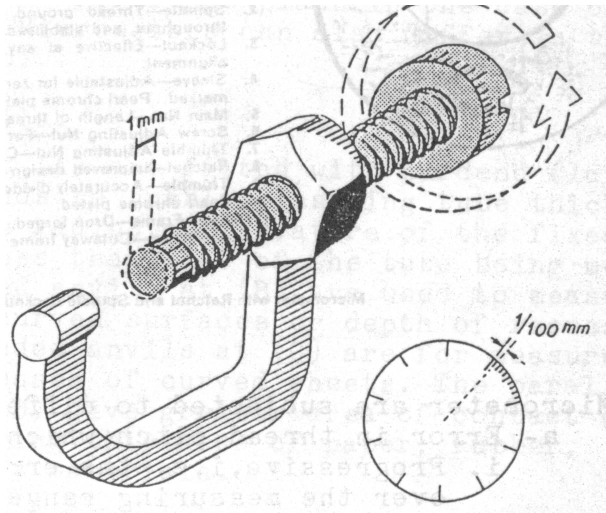
MICROMETERS

The micrometer is a precision measuring instrument, used by engineers. Each revolution of the rachet moves the spindle face 0.5mm towards the anvil face. The object to be measured is placed between the anvil face and the spindle face. The rachet is turned clockwise until the object is 'trapped' between these two surfaces and the rachet makes a 'clicking' noise. This means that the rachet cannot be tightened any more and the measurement can be read.



Working principle:

The function of micrometer is based on the principle of converting a rotary motion into a straight motion.



A single-start thread having a pitch of 0.5 mm, 1 mm or 1/40 inch is machined on a spindle, the left-hand side of witch forms the movable anvil. The thread is engaged with a main nut fixed to the frame of the micrometer through a screw joint. The second end of the spindle is rigidly secured to the thimble having a knurled finger grip and a graduated bevel portion on the left. The rotation of the thimble causes the spindle the move towards or away from the fixed anvil such that the spindle moves a distance equal to the pitch of the thread per revolution of the thimble. The motion of the spindle is read on a scale marked on the barrel of the fram to the nearest value of one pitch while the fraction of a revolution, is read on the beveled edge of the thimble.

$$M = \frac{C}{D} \frac{\pi D}{pitch}$$

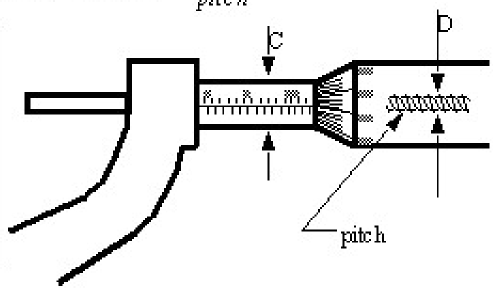
where,

M = magnification from the moving head to the hand motion
C = measuring diameter of the instrument
D = diameter of the thread
pitch = the number of threads per unit length

Radial Arm Principle of Magnification $? = \frac{C}{D}$

Inclined Plane Principle of Magnification $? = \frac{\pi D}{pitch}$

NOTE: magnification can result in greater sensitivity of an insrument to control, and reading by a user.



Micrometer are subjected to different types of errors:

a. Error in thread pitch which may be:

   i. Progressive, i.e. the error increases steadily over the measuring range. This may be due to wear on the thread or due to a graduation error.

   ii. Periodic, where the error increases and diminishes at regular intervals. This may be due to a fault in the manufacturing of the threads.

   Such errors can be corrected by calibrating the micrometer against slip gauges.

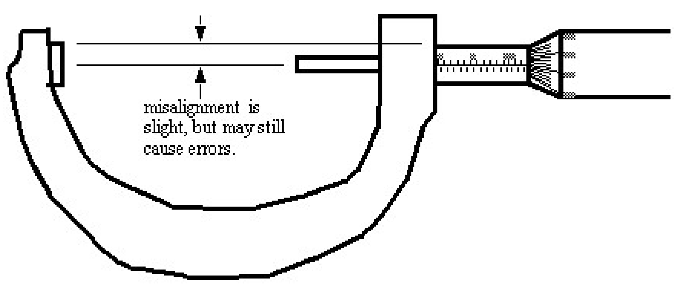
b. Error in flatness, squareness and parallelism.

   - The parallelism is checked by measuring the diameter of a standard accurate ball across at least 3 different points on the anvil faces.

- The squareness of the anvils to the measuring axis is checked by using two standard balls whose diameters differ by an odd multiple of half a pitch which calls for turning the movable anvil at 180° w.r.t. the fixed one.
- The flatness of the anvils is tested by the interference method using optical flats. The face must not show more than one complete interference band, i.e. must be within 0.25 μm.

C. Alignment error

Basically, the line of the physical measurement should be such that it is coincident with the measurement axis of the instrument. If the measurement is out of line, it may lead to mis-readings caused by deflections in the instrument.
Micrometers are generally better than sliding vernier calipers when considering this principle.

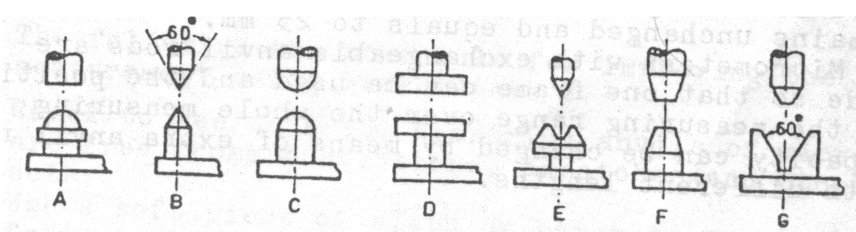


Types of micrometers:

The micrometer principle has a wide variety of applications in engineering metrology. Different designed are based upon the substitutions of special fittings in place of the plane surface contact anvils. In some other designed, the fixed anvil is substituted by a flat surface used as reference plane in the case of depth micrometer. Micrometers can also differ in the type of frame used.

(a) Types of anvils:

The anvils at (A) are fitted with hardened flat and spherical ends to enable measuring tube thickness. In such case the radius of curvature of the fixed anvil must be less than that of the tube being measured. The pointed anvils at (B) are used to measure thicknesses of curved surfaces or depth of recesses. The spherical ended anvils at (C) are for measurements of thicknesses of curved sheets. The parallel flat anvils at (D) give greater area of contact employed for measuring thickness of paper, rubber, cloth or any soft materials.



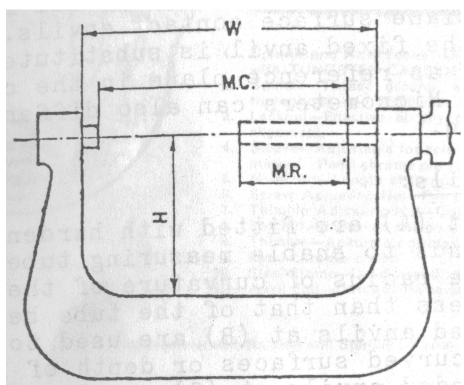
The arrangement of the V-formed fixed anvil together with a tapered movable anvil shown at (E) is used in connection with the measurement of the screw threads. The reduced diameter anvils at (F) are used for measuring the depth of keyways. The arrangement shown at (G) is used for measuring the diameter of odd fluted cylindrical parts as reamers. In this case the V-block should have an angle of 60^o and the sides should intersect at a point on the bottom surface.

The diameter of the anvil is usually 6.5 or 8 mm and it can be reduced if required to 1 or 2 mm.

Pointed anvils have a cone angle of 60^o or 55^o as required.

(b) Types of frames:

Usually the U-shaped frame is used. The width (W) of the frame determines the measuring capacity of the micrometer and its depth (H) gives the maximum diameter of the part being measured.



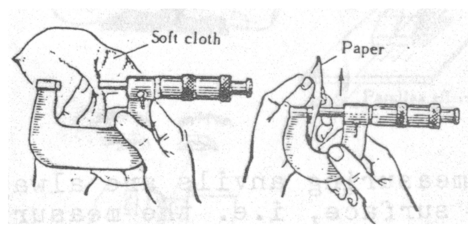
Standard U-frames are made according to the standard measuring capacities where the measuring range remains unchanged and equals to 25 mm.

Micrometers with exchangeable anvil rods are made so that one frame can be used and the position of the measuring range over the whole measuring capacity can be changed by means of extra anvil rods with different lengths.

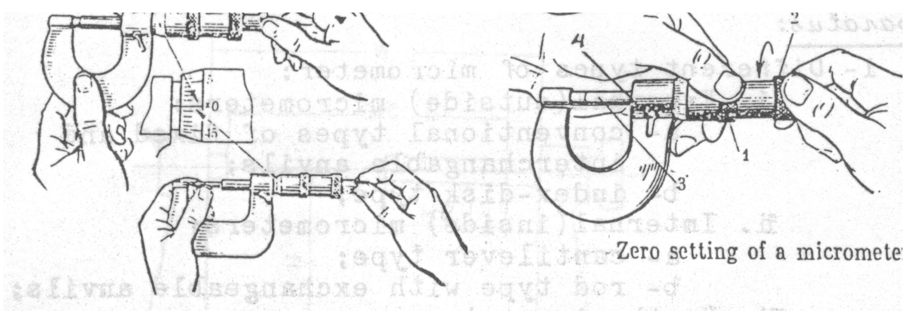
Precautions:

The following are some rule for improving the accrual of measurement using micrometers:

1. Check to see that the measuring anvils of micrometer are free from rust, score, scratches and other defects;
2. Use a soft piece of cloth or paper to remove grease from micrometer anvils and spindle:



3. Check the micrometer for accuracy of zero setting. If the zero mark does not coincide with the datum line; proceed as follows:

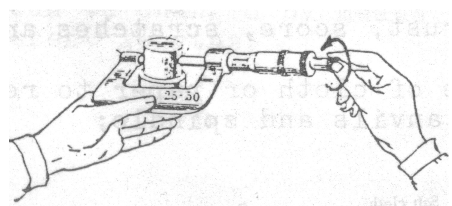


Zero setting of a micromete

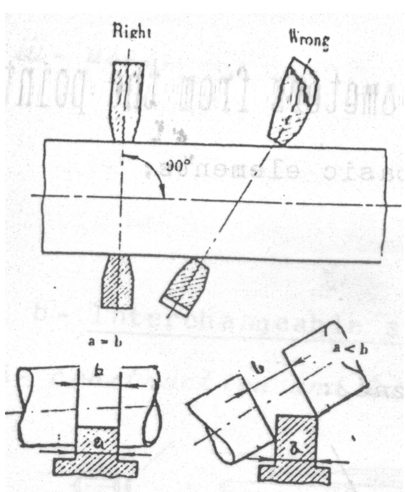
- Fix the spindle 3 with the lock 4. as you do so, be sure that the measuring surfaces are in contact. Release the cap 2 which couples the thimble to the spindle. Hold the tool by the knurled nut with your left hand.

- Disengage the thimble and the spindle, then turn the thimble until the zero mark on its rim is level with the datum line on the barrel.
- Tighten the cap 2 to couple the thimble to the spindle.

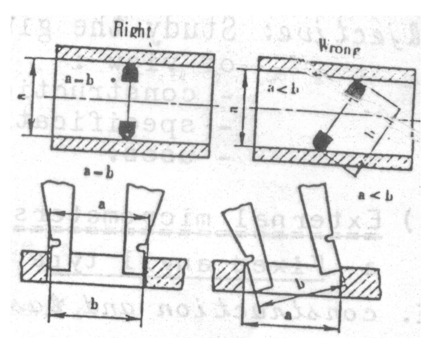
4. In order to reduce the liability of error due to the application of different measuring forces during measurement; the rachet knob is to be used.



5. Be sure that the measuring anvils are always at right angle to the work surface, i.e. the measuring axis is at right angles to the parts generatrix and passes through the centre. Otherwise the micrometer would read wrong value.



Measuring external surfaces

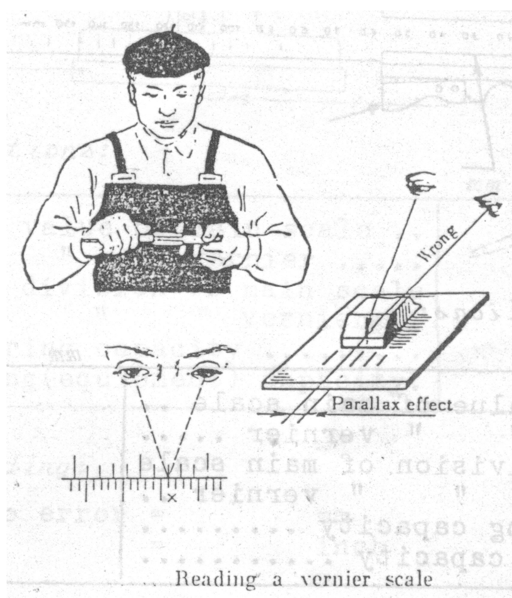


Measuring internal surfaces

6. Avoid touching the measuring surfaces with bare hands, and avoid holding the gauge in your hand too long; otherwise the temperature effect may result wrong reading.

7. When measuring with depth micrometer, the base of gauge must be pressed firmly on surface.

8. For taking micrometer reading, fix the spindle in place by turning the lock screw, then hold the tool straight before your eyes. Otherwise, the parallax effect may result in wrong reading.



Reading a vernier scale

THE EXPERIMENT

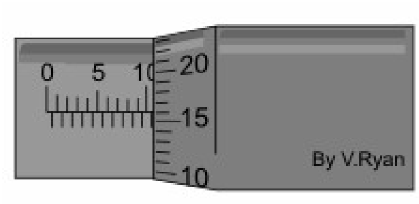
Main Objective:

To study the construction, specification purpose and application of different types of micrometer.

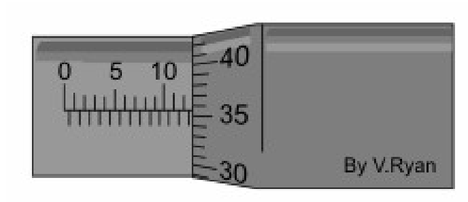
Apparatus:

1. Different types of micrometer:
    - ii. External (outside) micrometers:
        - a. Conventional types of fixed and interchangeable anvils;
        - b. Index-disk type;
    - iii. Internal (inside) micrometers:
        - a. Cantilever type;
        - b. Rod type with exchangeable anvils;
    - iv. Depth micrometer;
    - v. Special purpose micrometers:
        - a. Gear-span micrometer;
        - b. Screw-thread micrometer.
2. Universal fixture.
3. Surface plate.
4. A set of slip gauges.
5. Objects to be measured.

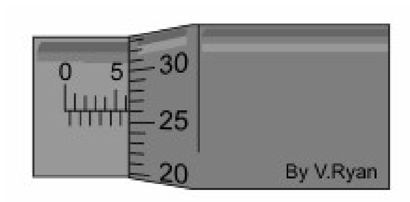
Read the following micrometers



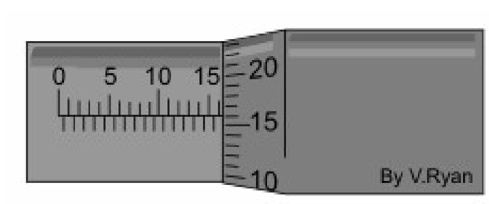
ANSWER:



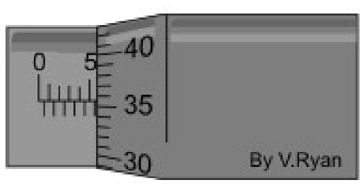
ANSWER:



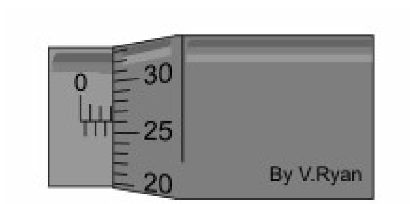
ANSWER:



ANSWER:



ANSWER:

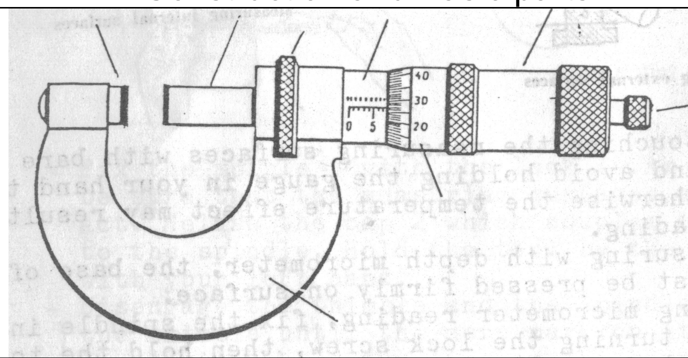


ANSWER:

Objective: Study the given micrometers according to the following points of view:

External Micrometer
Fixed anvil type

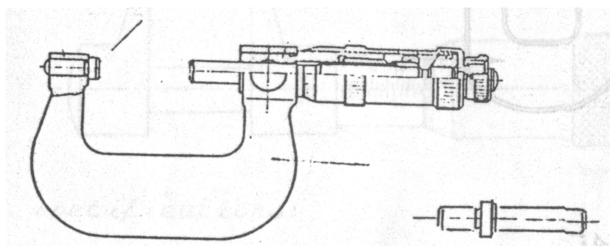
1-Construction and Basic parts



2- Specification

	mm	inch
Pitch of spindle screw (p) Diameter of spindle	= =	
<u>Sleeve Scale specifications</u> Scale division Scale value	 = =	
<u>Thimble Scale specifications</u> No. of divisions (n) Thimble diameter (d) Scale division (Лd/n) Scale value(P/n)	 = = = =	
<u>Vernier specifications:</u> No. of divisions (m) Scale division (1-1/m)P/n Scale value(1/m)P/n	 = = =	
<u>Overall specifications:</u>		

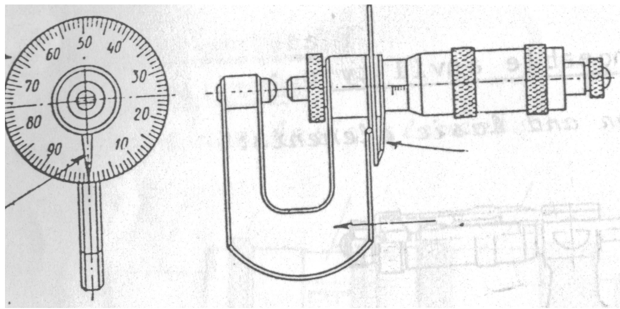
Measuring capacity Working capacity	= =	
4- Uses		

External Micrometer Interchangeable anvil type	
1-Construction and Basic parts	
	
	mm
Pitch of spindle screw (p) Diameter of spindle	
Sleeve Scale specifications Scale division Scale value	
Thimble Scale specifications No. of divisions (n) Thimble diameter (d) Scale division (Лd/n) Scale value(P/n)	
Overall specifications: Measuring capacity Working capacity	
Uses	

External Micrometer

Index Disk type

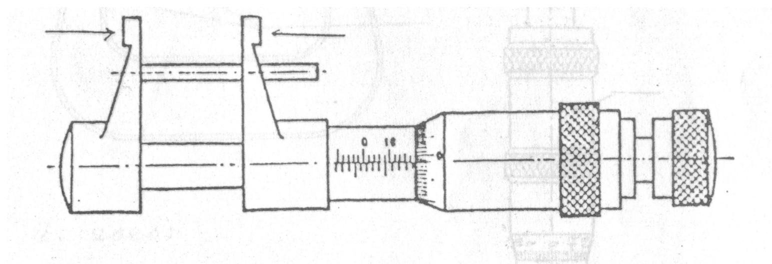
1-Construction and Basic parts

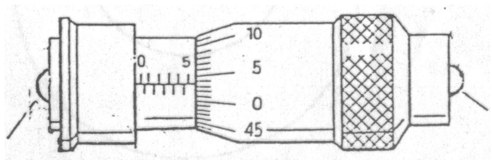


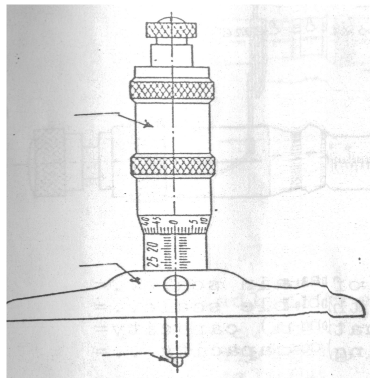
2- Specification

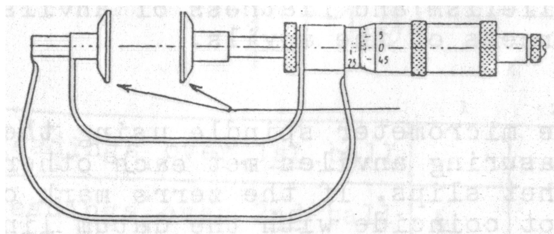
	mm	inch
Pitch of spindle screw (p)		
Diameter of spindle		
<u>Sleeve Scale specifications</u>		
Scale division		
Scale value		
<u>Thimble Scale specifications</u>		
No. of divisions (n)		
Thimble diameter (d)		
Scale division (Лd/n)		
Scale value(P/n)		
<u>Overall specifications:</u>		
Measuring capacity		
Working capacity		

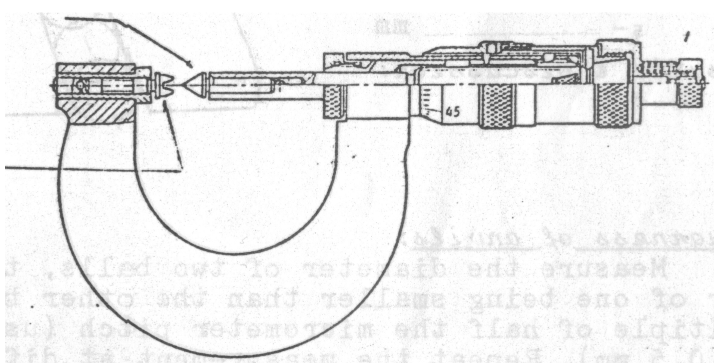
4- Uses

<table>
<tr><td colspan="2">Internal Micrometer
(a)Cantilever type</td></tr>
<tr><td colspan="2">1-Construction and Basic parts</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">2- Specification</td></tr>
<tr><td></td><td>mm</td></tr>
<tr><td rowspan="2">Pitch of spindle screw (p)
Diameter of spindle</td><td></td></tr>
<tr><td></td></tr>
<tr><td rowspan="2"><u>Sleeve Scale specifications</u>
Scale division
Scale value</td><td></td></tr>
<tr><td></td></tr>
<tr><td rowspan="2"><u>Thimble Scale specifications</u>
Scale division (Лd/n)
Scale value(P/n)</td><td></td></tr>
<tr><td></td></tr>
<tr><td><u>Overall specifications:</u>
Measuring capacity
Working capacity</td><td></td></tr>
<tr><td colspan="2">4- Uses</td></tr>
<tr><td colspan="2"></td></tr>
</table>

<table>
<tr><td colspan="2">Internal Micrometer
(b) Rod type (with exchangeable anvils)</td></tr>
<tr><td colspan="2">1-Construction and Basic parts</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">2- Specification</td></tr>
<tr><td></td><td>mm</td></tr>
<tr><td>Pitch of spindle screw (p)
Diameter of spindle</td><td></td></tr>
<tr><td><u>Sleeve Scale specifications</u>
Scale division
Scale value</td><td></td></tr>
<tr><td><u>Thimble Scale specifications</u>
Scale division (Лd/n)
Scale value(P/n)</td><td></td></tr>
<tr><td><u>Overall specifications:</u>
Measuring capacity
Working capacity</td><td></td></tr>
<tr><td colspan="2">4- Uses</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Depth Micrometer		
1-Construction and Basic parts		
		
2- Specification		
	mm	
Pitch of spindle screw (p)		
Diameter of spindle		
Sleeve Scale specifications		
Scale division		
Scale value		
Thimble Scale specifications		
Scale division (Лd/n)		
Scale value(P/n)		
Overall specifications:		
Measuring capacity		
Working capacity		
Maximum depth of W.P.		
Maximum width of W.P.		
4- Uses		

Special purpose micrometers (a) Gear Tooth micrometer	
1-Construction and Basic parts	
	
2- Specification	
	mm
<u>Sleeve Scale specifications</u> Scale value	
<u>Thimble Scale specifications</u> Scale value(P/n)	
<u>Overall specifications:</u> Measuring capacity Working capacity	
4- Uses	

<table>
<tr><td colspan="2">Special purpose micrometers
(b) Screw thread micrometer</td></tr>
<tr><td colspan="2">1-Construction and Basic parts</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">2- Specification</td></tr>
<tr><td></td><td>mm</td></tr>
<tr><td rowspan="2"><u>Sleeve Scale specifications</u>
Scale value</td><td></td></tr>
<tr><td></td></tr>
<tr><td rowspan="2"><u>Thimble Scale specifications</u>
Scale value(P/n)</td><td></td></tr>
<tr><td></td></tr>
<tr><td><u>Overall specifications:</u>
Measuring capacity
Working capacity</td><td></td></tr>
<tr><td colspan="2">4- Uses</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">5- Types of anvils</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Objective:

Check one of the external micrometer for:

- Zero error;
- Parallelism and flatness of anvils;
- Squareness of the anvils.

i. Zero error:

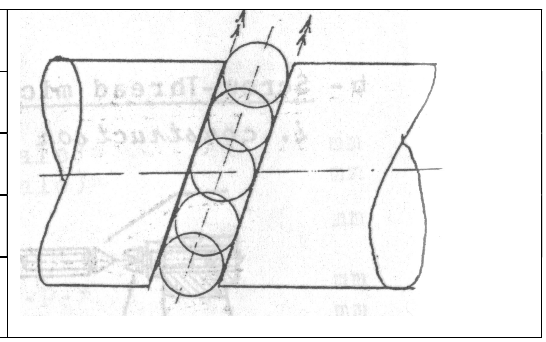
Turn the micrometer spindle using the ratchet until the measuring anvils met each other, i.e. till the rachet slips. If the zero mark of thimble scale does not coincide with the datum line on the barrel; a zero error is found.

Zero error = mm

ii. Parallelism & flatness:

Measure the diameter of an accurate ball at different points across the anvils. The correct flatness and parallelism is that the readings do not vary from point to point.

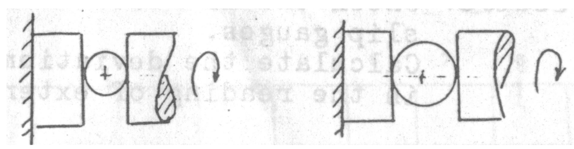
- Readings at diff. points:

1		
2		
3		
4		
5		

- Results & Discussion:

iii. Squareness of anvils:

Measure the diameter of two balls, the diameter of one being smaller than the other by any odd multiple of half the micrometer pitch (usually 0.25 or 0.5 mm). Repeat the measurement at different points across the anvil. The anvils are square if the difference in the reading corresponds to the true difference in the diameters of the balls.



Readings:

Diameter of first ball (D1) = mm

Diameter of second ball (D2) = mm

Difference between ball diameters = D1 – D2 = mm

Readings over 1st ball					
Reading over 2nd ball					
Difference in readings					

Results & Discussion:

Objective:

Check the micrometer for hysterisis using slip gauges.

Calculate the deviation due to hysterisis in the reading of external micrometer.

Procedure:

- Set the micrometer to read 5 mm by moving the anvil in the right hand direction only. Measure the distance between the anvils using slip gauges. Repeat this 5 times.
- Set the micrometer to read the same value as before but by moving the anvil to the left only and measure the distance between the anvil. Repeat this 5 times.
- Calculate the true deviation due to hysterisis out of these 10 readings

Average deviation $(\sigma) = \pm\sqrt{\dfrac{\sum(\bar{x} - x)^2}{n - 1}}$

Where:

Average of observation $(\bar{x}) = \dfrac{\sum x}{n}$

Readings & calculations:

No.	Reading (x)	$(\bar{x}-x)$	$(\bar{x}-x)^2$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
$\sum x =$		$\sum(\bar{x}-x)^2 =$	

No. of observations (n) =

$\bar{x} = (\sum x)/n =$

$J = \pm\sum(\bar{x}-x)^2/(n-1) =$

Objective

Check the linearity of the given micrometer, whithin its measuring capacity using slip gauges. Draw the calibration curve and show the zero error and measuring range

Reading:

	1	2	3	4	5	6	7	8	9	10
Slip gauge										
Micrometer										

Calibration Curve

Results and Discussion

Zerro error=

Measuring range**=**

Appendix 1

THE USE, CARE AND ADJUSTMENT OF MICROMETERS

A micrometer should not be held in the hand longer than necessary as it is so sensitive that prolonged hand heat will cause expansion and subsequent inaccuracies in measurement.

External micrometers measuring up to 25 mm (1°) can easily be used in one hand as shown below, but as far as possible they should not be gripped tightly.

When using larger micrometers rest the frame in one hand, and turn the thimble with the other. The very large tubular framed micrometers can be supplied with insulator hand grips if desired.

When taking a measurement keep the measuring faces square with the object being measured. Do not use undue force in bringing the contacting surfaces together otherwise serious damage may be done to the measuring faces. Use the ratchet or friction drive, if one is fitted, as this gives uniform pressure and ensures consistent reading.

Always see that the anvil faces are clean, a merest suspicion of dirt or oil can give an appreciable error. To clean the faces of micrometers where anvil and spindle meet, e.g. 0 – 12 mm (0 1 1/2) and 0 – 25 mm (0 – 1°); open the anvil and spindle faces slightly and insert a piece of paper between them. Close the faces so that the paper is lightly griped between them, then withdraw the paper by sliding it out and any dirt or grease will be removed.

Use an absorbent paper to clean the faces on micrometers where the anvil and spindle do no meet.

Do not leave a micrometer lying about on a bench or machine bed since it can so easily be knocked or to the floor and damaged. Keep it in the box in which it was supplied as this will help to keep the micrometer clean and free from dust and grease.

After using micrometer it should be wiped over carefully to remove any foreign matter and then be replaced in its protective box or case. If it is not to be used again for some time, wipe it carefully, and put a thin coat of good quality non-corrosive oil on the measuring faces and bright spots. An oll with a lanolin base is most suitable for this job. It is no usually necessary to lubricate the screw as it will be seen from the illustration above, that the form of thread is such that the truncations at the crest and root provide for oll retention.

To adjust an mm micrometer use the special spanner which is supplied with it. Any looseness in the screw can be taken up by a slight turn of the adjusting nut, which can be reached by unscrewing the spindle.

Errors arising in zero reading or from wear on the measuring faces are corrected by means of the adjustable sleeve. Clean the faces and bring them carefully together, then turn the sleeve with the spanner until the zero lines on the sleeve and on the thimble coincide. In the case of micrometers larger than 25 mm (1°) it will not be possible to make the faces contact and the appropriate setting gauge must be used.

On micrometers with interchangeable anvils, or extension rods, one particular rod may receive an undue amount of wear. Do not attempt to correct this by solving the sleeve or the setting to the remaining rods will be rendered inaccurate. Provision is made on the rods to make the proper adjustment by means of locknuts or screwed inserts.

With care micrometer should continue to give accurate reading for a considerable period of use. If, however, any repairs or renovations should become necessary the Moore & Wright Service Department is always at the customer's disposal.

Appendix 2

READING THE METRIC MICROMETER

Reading in Hundredths of a Millimetre (0.01 mm)

Metric micrometers can be read to one hundredth of a millimeter (0.01 mm). As the screw on metric micrometers has a pitch of 1/2 mm so two revolutions of the thimble will move the spindle through 1 mm. On the sleeve the datum line is graduated with two sets of lines – the set below the line reading in millimeters and the set above the line reading in half millimeters.

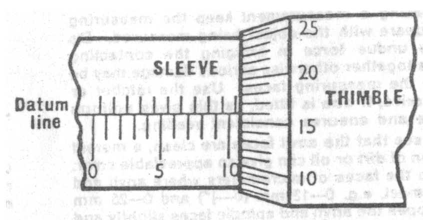


Fig. 1

(N.B. On earlier models the millimeters are graduated above the datum line with half millimeters below).

The thimble is divided into fifty equal divisions, figured in fives, so that each small division on the thimble represents 1/50 of 1/2 mm which equals 1/100 mm (0.01 mm).

To read the metric micrometer, first note the whole number of millimeter divisions on the sleeve (JAJOR divisions) then observe whether there is a half millimeter visible (MINOR divisions) and lastly read the thimble for hundredths (THIMBLE divisions) i.e. the line on the thimble coinciding with the datum line.

Example: (Fig. 1)

MAJOR Divisions	= 10 x 1.00 mm	= 10.00 mm
MINOR Divisions	= 1 x 0.50 mm	= 0.50 mm
THIMBLE Divisions	= 16 x 0.01 mm	= 0.16 mm
	Reading	= 10.66 mm

Reading in Two Thousandths of a Millimetre (0.002 mm)

The Metric Vernier Micrometer is exactly as the ordinary metric micrometer with the additions of a vernier scale on the sleeve reading in conjunction with the thimble.

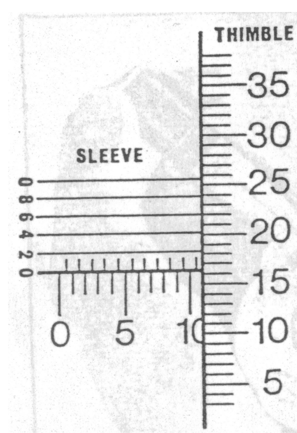


Fig. 2

On the sleeve parallel to the datum line are graduated five divisions which occupy the same space as nine divisions on the thimble, each division on the vernier scale representing two thousandths of a millimeter (0.002 mm).

To take a reading on a metric vernier micrometer it is necessary to note which vernier line coincides with a graduated line on the thimble; this gives the number of two thousandths of a millimeter to be added to the hundredths reading.

Where there is no coincidence of the lines, then the intermediate thousandths can be estimated, i.e. if the reading lies between four and six, then the additional thousandth reading would be 0.005 mm.

Example: (Fig. 2)

MAJOR Divisions	= 10 x 1.00 mm	= 10.00 mm
MINOR Divisions	= 1 x 0.50 mm	= 0.50 mm
THIMBLE Divisions	= 16 x 0.01 mm	= 0.16 mm
VERNIER Divisions	= 3 x 0.002 mm	= 0.006 mm
	Reading	= 10.666 mm

VERNIER line coincident with line on THIMBLE, e.g. 3rd Division is marked 6 which can also be read directly as 0.006 mm.

READING THE INCH MICROMETER

Reading in Thousandths of an inch (1/1,000 or 0.001°)

The inch reading micrometer screw has 40 threads per inch, so that in one complete revolution it moves 1/40° (0.025°) and in 1/25 of a turn it will move 1/25 of 1/40° which is 0.001°.

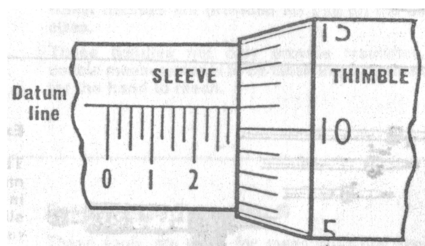


Fig. 3

The sleeve has marked on it MAJOR divisions representing tenths of an inch – that is 0.100° each. Every MAJOR division is sub-divided into four MINOR divisions representing 0.025° each.

The thimble is divided into twenty-five equal divisions and as one full turn is equal to one MINOR division on the sleeve (0.025°) then one division on the thimble will be 0.001°.

Thus to read the setting shown, count the number of tenths (MAJOR divisions), add the number of MINOR divisions multiplied by 0.025°, then add the number of thousandth divisions on the thimble (THIMBLE divisions) i.e. the line on the thimble coinciding with the datum line.

Example: (Fig. 3)

MAJOR Division	= 2 x 0.100°	= 0.200°
MINOR Divisions	= 3 x 0.025°	= 0.075°
THIMBLE Divisions	= 11 x 0.001°	= 0.011°
	Reading	= 0.286°

Reading in Ten-Thousandths of an inch (1/10,000 or 0.0001°)

The vernier micrometer is exactly as the ordinary micrometer with the addition of a vernier scale on the sleeve reading in conjunction with the thimble.

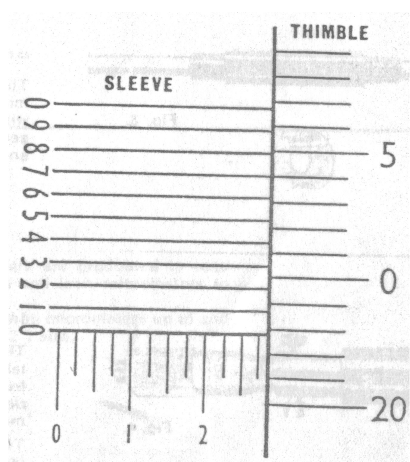


Fig. 4

On the sleeve parallel to the datum line are graduated ten divisions which occupy the same space as nine divisions on the thimble. Thus one vernier division equals 1/10 x 9/1,000 which is 9/10,000. The difference between a vernier and thimble division is 10/10,000 minus 9/10,000 which is 1/10,000 or 0.0001°.

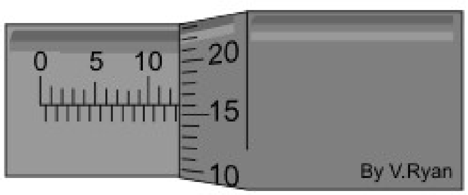
To take a reading on a vernier micrometer it is necessary to note which vernier line coincides with a graduated line on the thimble;

this gives the number of ten-thousands 90.0001^{o}) to be added to the standard thousandths reading.

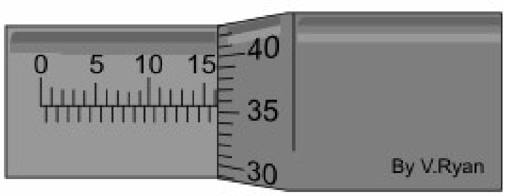
Example: (Fig. 4)

MAJOR Divisions	= 2 x 0.100^{o}	= 0.200^{o}
MINOR Divisions	= 3 x 0.025^{o}	= 0.075^{o}
THIMBLE Divisions	= 22 x 0.001^{o}	= 0.022^{o}
VERNIER Divisions	= 7 x 0.0001^{o}	= 0.0007^{o}
	Reading	= 0.2977^{o}

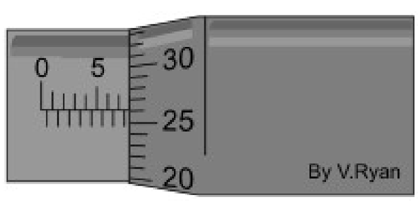
Additional reading examples



SLEEVE READS FULL mm = 12.00
SLEEVE READS ½ mm = 0.50
THIMBLE READS = 0.16
TOTAL MEASUREMENT = 12.66mm



SLEEVE READS FULL mm = 16.00
SLEEVE READS ½ mm = 0
THIMBLE READS = 0.355
TOTAL MEASUREMENT = 16.355mm



SLEEVE READS FULL mm = 7.00
SLEEVE READS ½ mm = 0.50
THIMBLE READS = 0.26
TOTAL MEASUREMENT = 7.76mm