INSPECTION

Introduction

- Precision measurement
  - Measurement of tolerances tighter than 1/64 or 1/100 of an inch, 0.5mm, or 1 degree
  - Semi precision tools not adequate

What is Precision Measurement?

- English measurements
  - Usually between 0.001 and 0.0001 inch
- SI (metric) measurements
  - 0.01 and 0.002mm
- Angular accuracy
  - 5 minutes (1/12 degree)
- Language of precision dimensions

Examples of Sizes Using the Machining Language	
Size/Dimension	**Spoken as:**
1.245	One inch, two hundred forty-five thousandths or *just* One inch, two-forty-five
0.137	One hundred thirty-seven thousandths or *just* One-thirty-seven
0.7588	Seven hundred fifty-eight and eight tenths
3.25	Three inches, two hundred fifty thousandths or *just* Three inches, two-fifty
0.1	One hundred thousandths or *just* One hundred
0.32	Three hundred twenty thousandths or *just* three-twenty
0.2204	Two hundred twenty and four tenths

FIGURE 2.4.1 Sizes in the language of machining.

Care of Precision Tools

- Precision measuring tools are delicate and expensive
- Care must be taken during use and storage

Straight Edges

- Check for flatness
- Place across a surface
  - If there is space between it and the surface, the surface is not flat

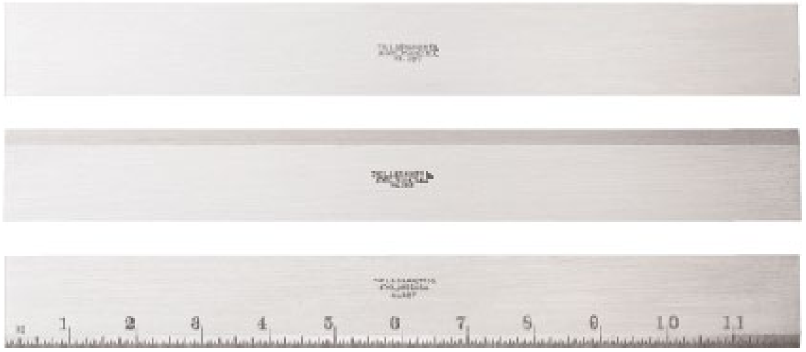

FIGURE 2.4.2 Some examples of straight edges.
Courtesy of The L. S. Starrett Company

Precision Fixed Gages

- Comparative measurements against known sizes
  - Thickness gages, pin or plug gages, ring gages, and snap gages

FIGURE 2.4.3 Examples of thickness gages.

FIGURE 2.4.4 A set of pin gages in 0.001” increments from 0.011” to 0.060”.

Gage Classes	
Gage Class	**Accuracy**
Class ZZ	(Least accurate)
Class Z	
Class Y	
Class X	
Class XX	
Class XXX	(Most accurate)

FIGURE 2.4.5 gage classes.

Courtesy of Vermont Gage

FIGURE 2.4.7 A go/no-go plug gage purchased to check a particular hole size. Note that the go member is longer than the no-go member.

FIGURE 2.4.9 Two typical go/no-go thread plug gages. The go member is either marked as green or is longer than the no-go member, just like a plain plug gage.

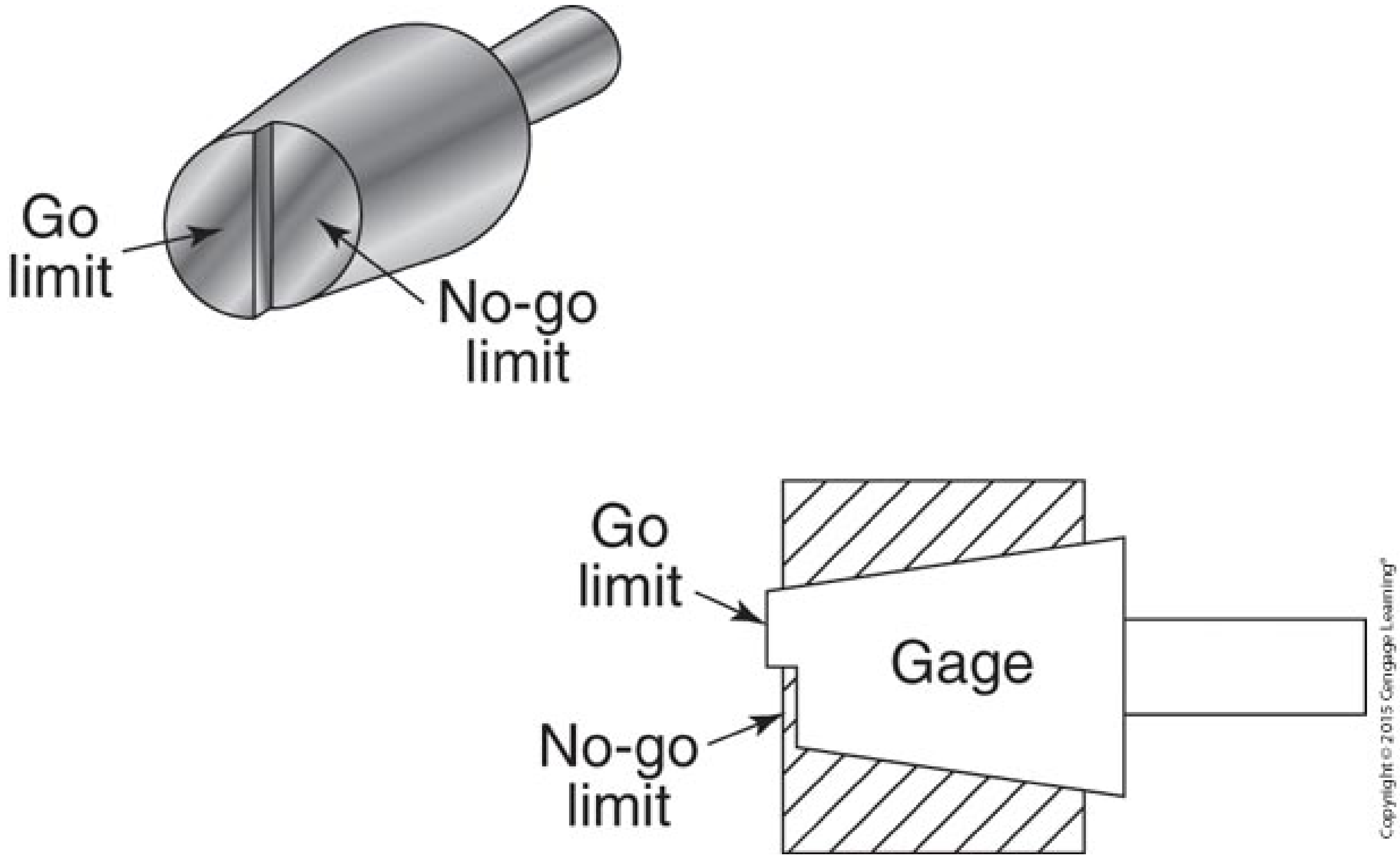

FIGURE 2.4.11 A step on the front of a taper plug gage can indicate the go and no-go limits. If the end of the part to be checked is between the two end surfaces, the part is within tolerance.

FIGURE 2.4.12 Go and no-go plain ring gages. Note the groove around the circumference to identify the no-go gauge.

Courtesy of Flexbar Machine Corp

Courtesy of Flexbar Machine Corp

FIGURE 2.4.15 Two styles of snap gages. The outer anvils of the snap gages are set to the go limit and should always pass over the part being checked. If they do not pass, the part is too large. The inner anvils are set to the no-go limit and should not pass over the part. If they do, the part is too small.

SURFACE PLATES

- Flat plate used as accurate reference surface for other precision tools
- Most are made of granite
- Three different grades of flatness

FIGURE 2.4.18 Examples of typical surface plates.

Solid Squares

- More precise than adjustable squares
- Available in a wide variety of sizes

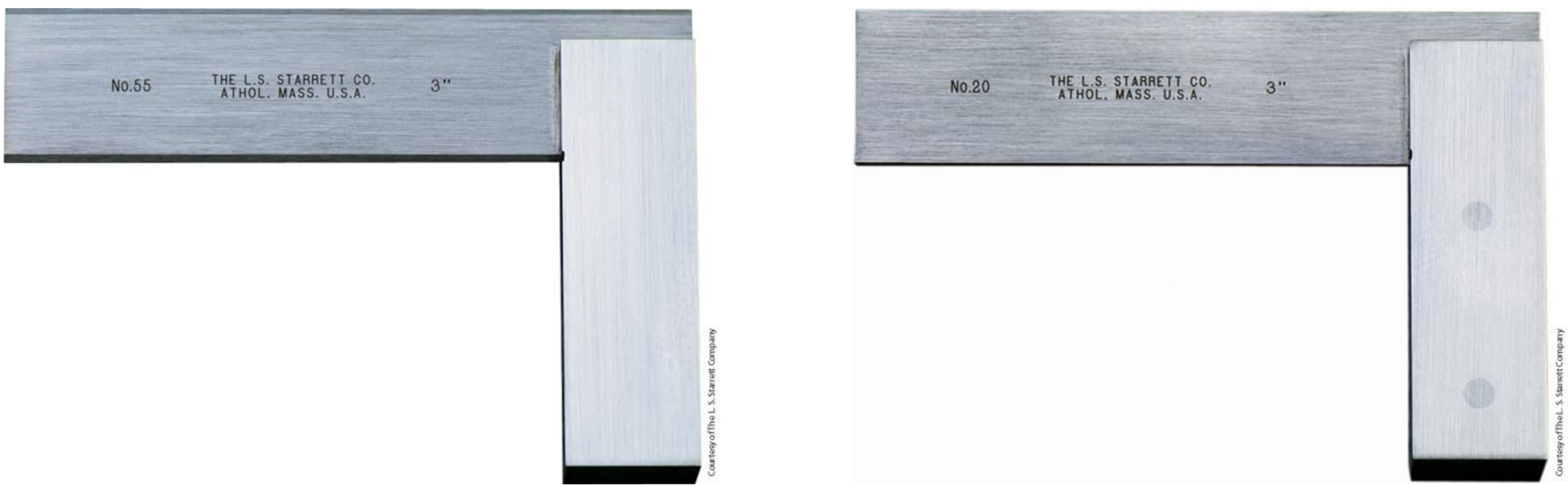

FIGURE 2.4.19 Two types of solid squares. The blade of the model on the right has beveled edges.

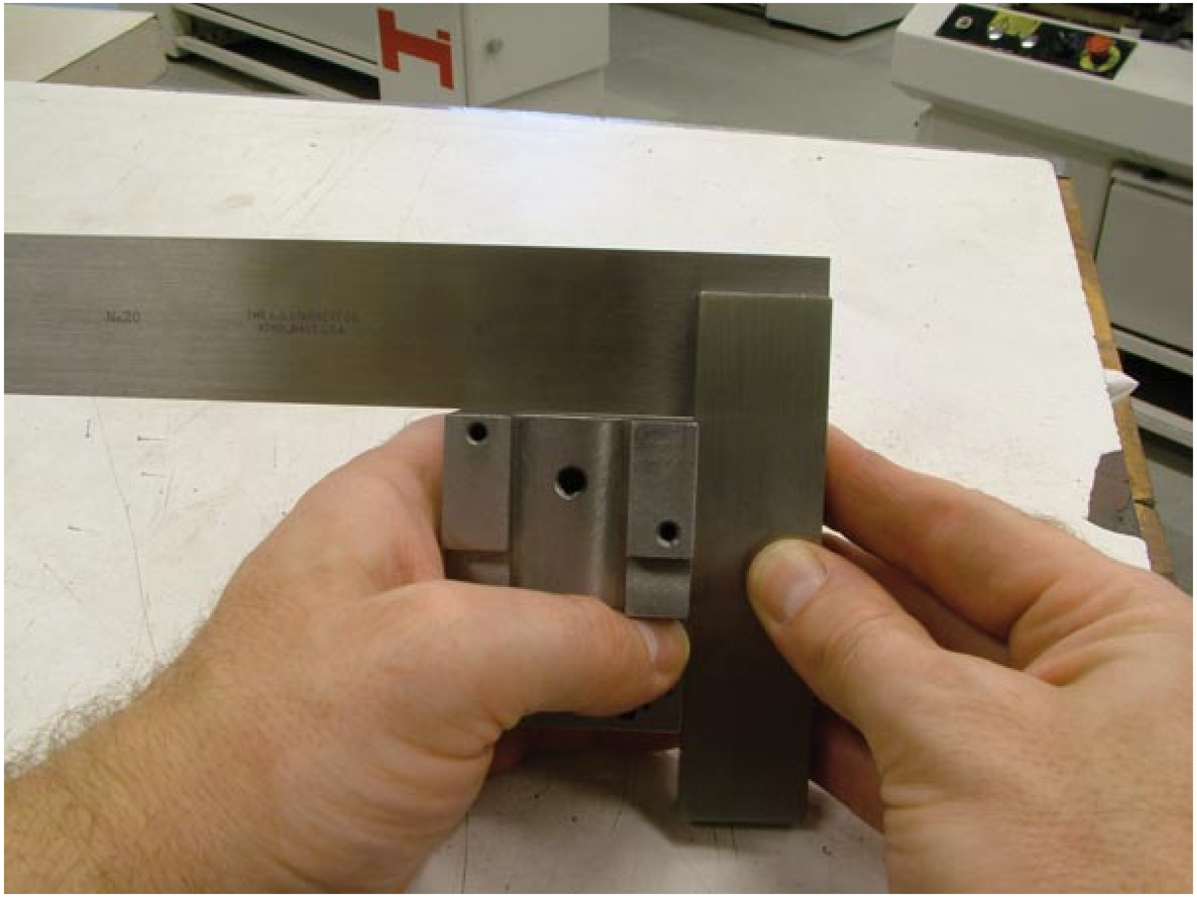

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FIGURE 2.4.20 Checking two surfaces for square (perpendicularity) with a solid square. The light showing between the part and the blade at the inner corner indicates the two surfaces are “out of square.”

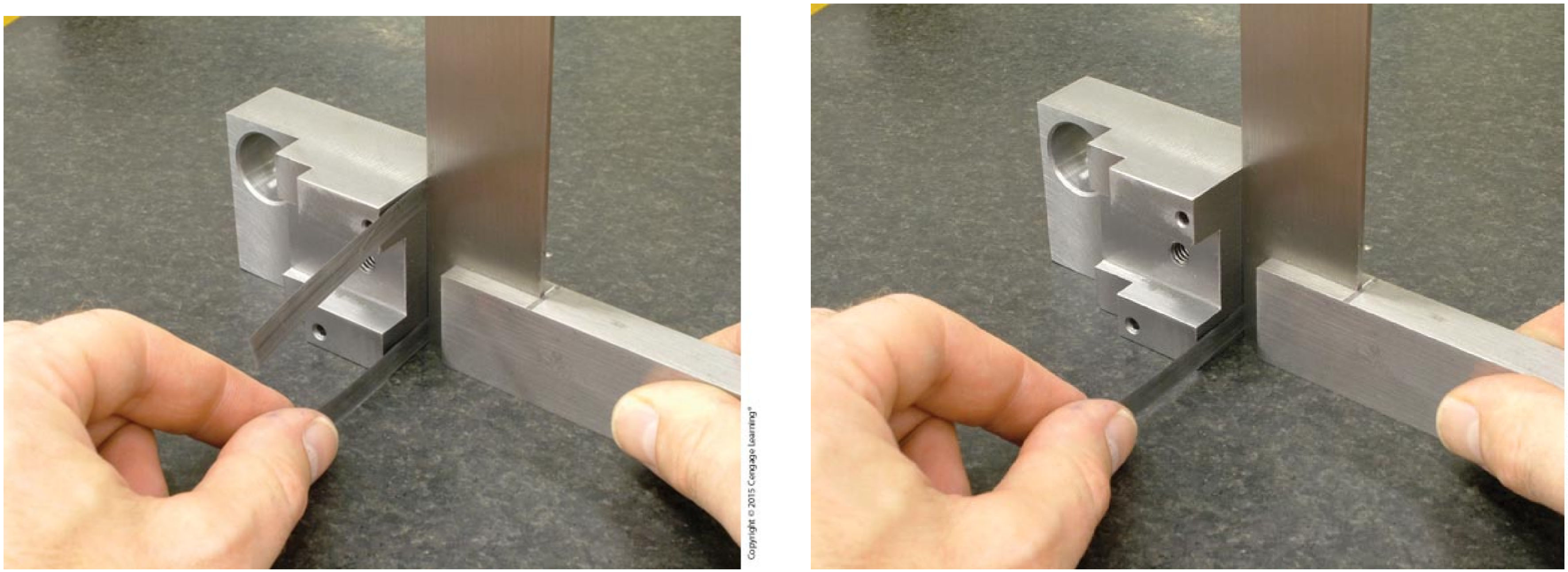


FIGURE 2.4.22 Checking for the amount of perpendicularity error.

Gage Blocks

- Accurately sized blocks for inspections or testing accuracy of other tools
- Available in different grades of accuracy
- Different size blocks can be wrung together
  - Called gage block builds
  - When creating, the fewest number of blocks should be used

Gage block grades and their tolerances.

	Tolerance in Millionths of an Inch (0.000001) for Each Gage Block Grade			
Individual Gage Block Sizes in Inches	Grade 00	Grade 0	Grade AS1	Grade AS2
Thru 0.0500	+4 / –4	+6 / –6	+12 / –12	+24 / –24
Over 0.0500 through 0.4000	+3 / –3	+5 / –5	+8 / –8	+18 / –18
Over 0.4000 through 1.0000	+3 / –3	+6 / –6	+12 / –12	+24 / –24
Over 1.0000 through 2.0000	+4 / –4	+8 / –8	+16 / –16	+32 / –32
Over 2.0000 through 3.0000	+5 / –5	+10 / –10	+20 / –20	+40 / –40
Over 3.0000 through 4.0000	+6 / –6	+12 / –12	+24 / –24	+48 / –48

0.050	0.102	0.114	0.126	0.138	0.150	0.750
0.100	0.103	0.115	0.127	0.139	0.200	0.800
0.1001	0.104	0.116	0.128	0.140	0.250	0.850
0.1002	0.105	0.117	0.129	0.141	0.300	0.900
0.1003	0.106	0.118	0.130	0.142	0.350	0.950
0.1004	0.107	0.119	0.131	0.143	0.400	1.000
0.1005	0.108	0.120	0.132	0.144	0.450	2.000
0.1006	0.109	0.121	0.133	0.145	0.500	3.000
0.1007	0.110	0.122	0.134	0.146	0.550	4.000
0.1008	0.111	0.123	0.135	0.147	0.600	
0.1009	0.112	0.124	0.136	0.148	0.650	
0.101	0.113	0.125	0.137	0.149	0.700	
0.0625 (1/16)	0.078125 (5/64)	0.093750 (3/32)	0.109375 (7/64)	0.100025	0.100050	0.100075

FIGURE 2.4.25 Block sizes of an 88-piece inch-based gage block set.

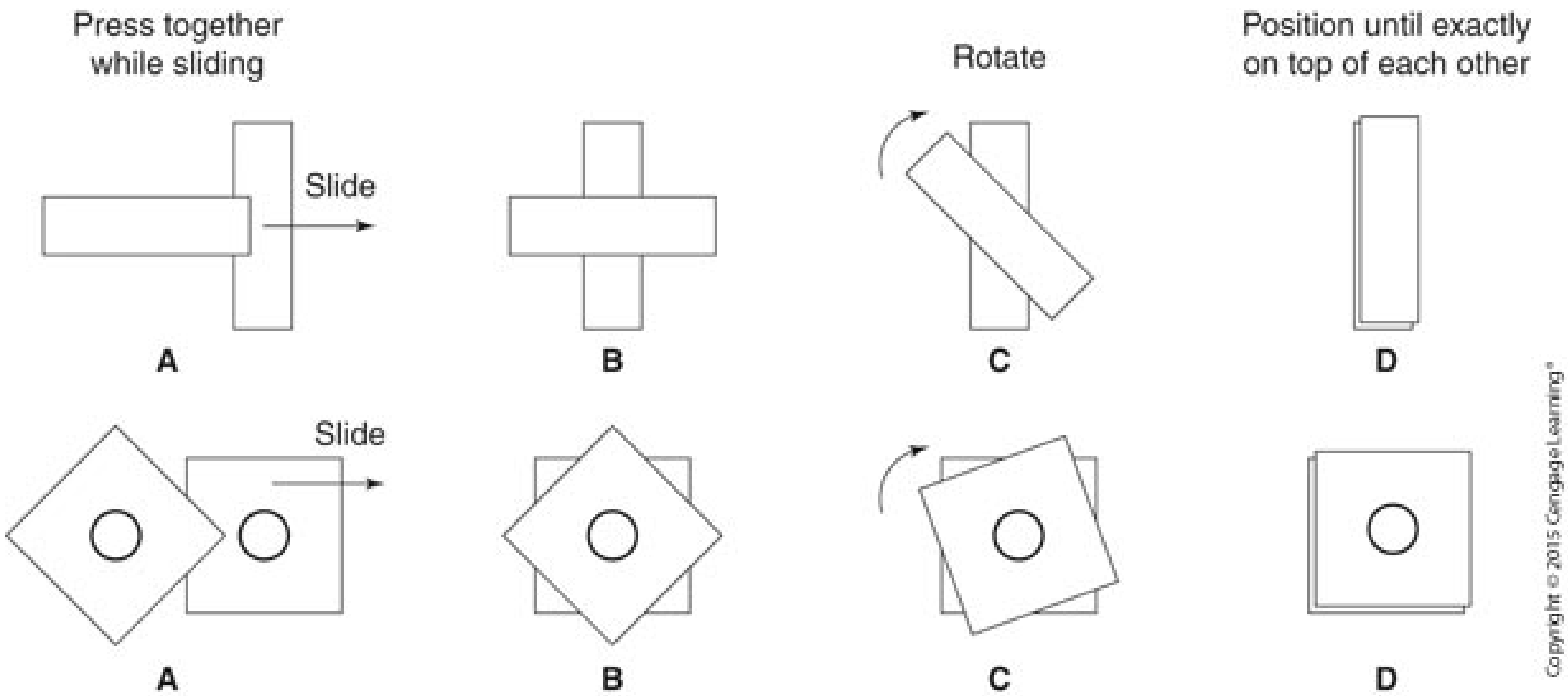


FIGURE 2.4.26 Steps for wringing gage blocks together. Using this process, virtually any size build can be created.

Vernier Measuring Tools

- Contain main scale and secondary sliding scale called the vernier scale
  - Types include calipers, height gages, depth gages, gear tooth calipers, and protractors
  - Linear tools available with either a 25- or 50-part vernier scale
  - Line on the vernier scale aligns with main scale

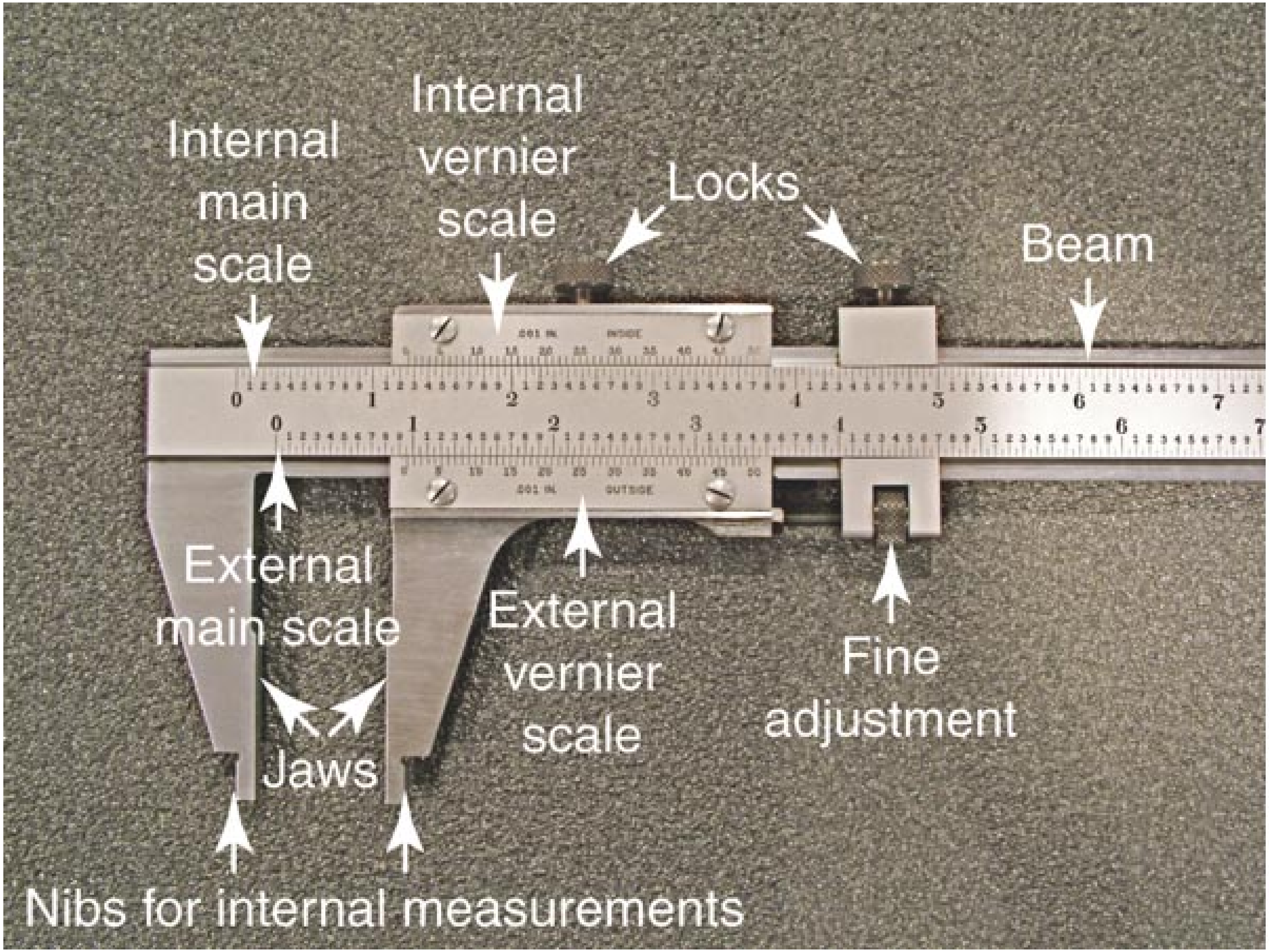


FIGURE 2.4.31 Parts of a vernier caliper.

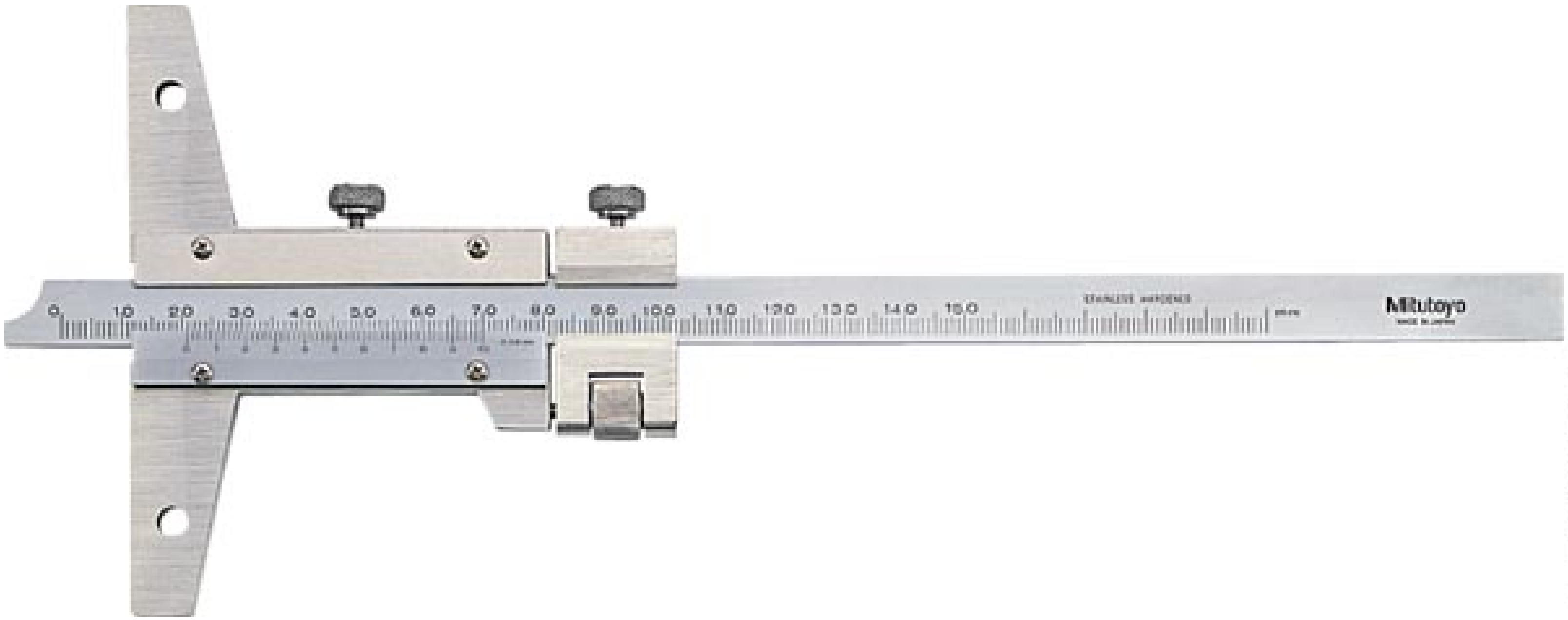
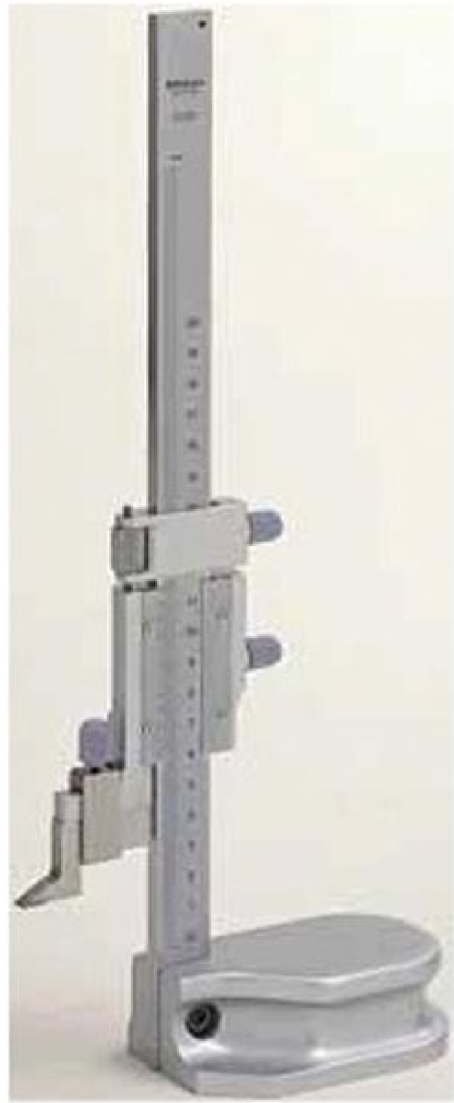
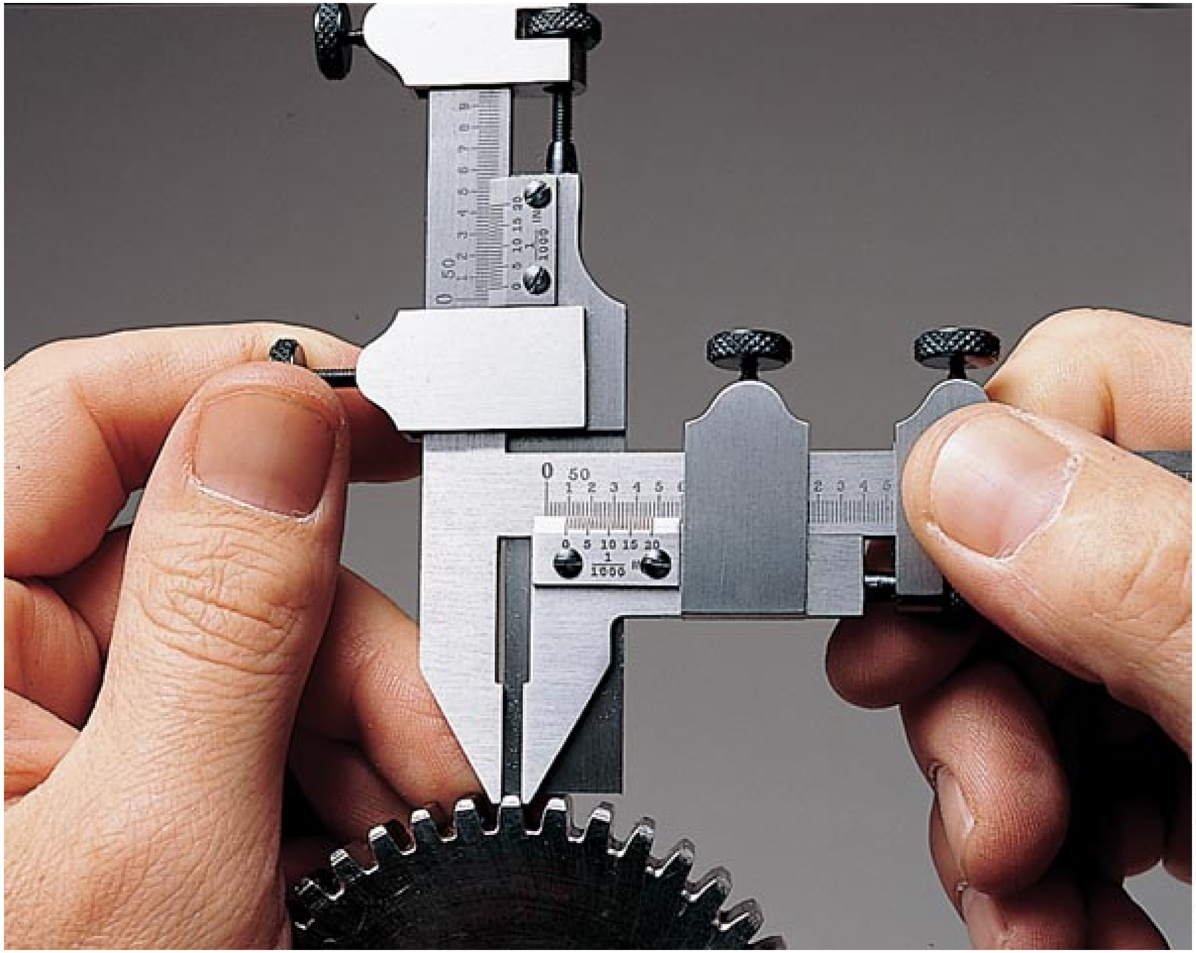


FIGURE 2.4.33 A vernier depth gage.

FIGURE 2.4.32 A vernier height gage.





Courtesy The L.S. Starrett Company

FIGURE 2.4.34 A vernier gear tooth caliper measures gear tooth width at a preset depth. Note the vertical and horizontal scales.

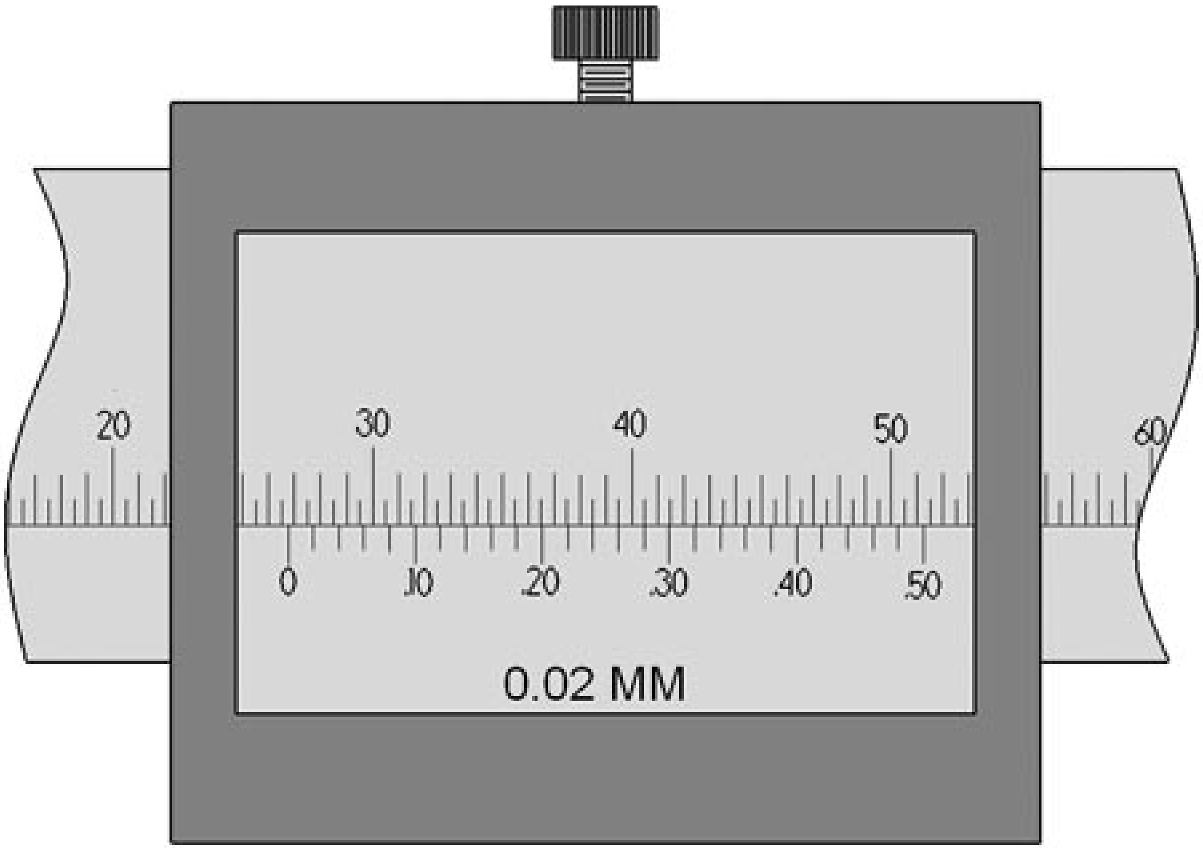


FIGURE 2.4.40 The 25-part metric vernier scale.

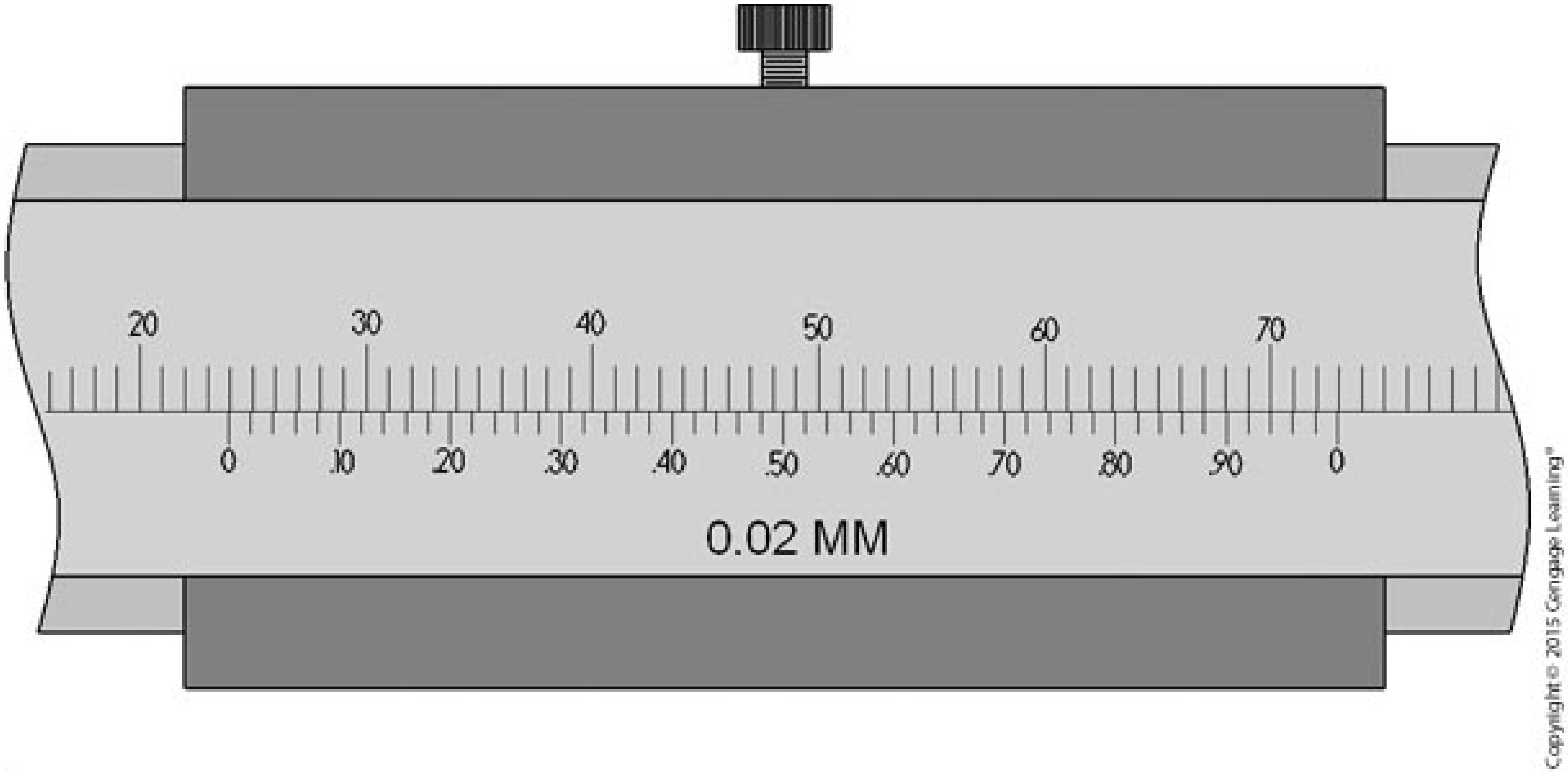


FIGURE 2.4.42 The 50-part metric vernier scale.

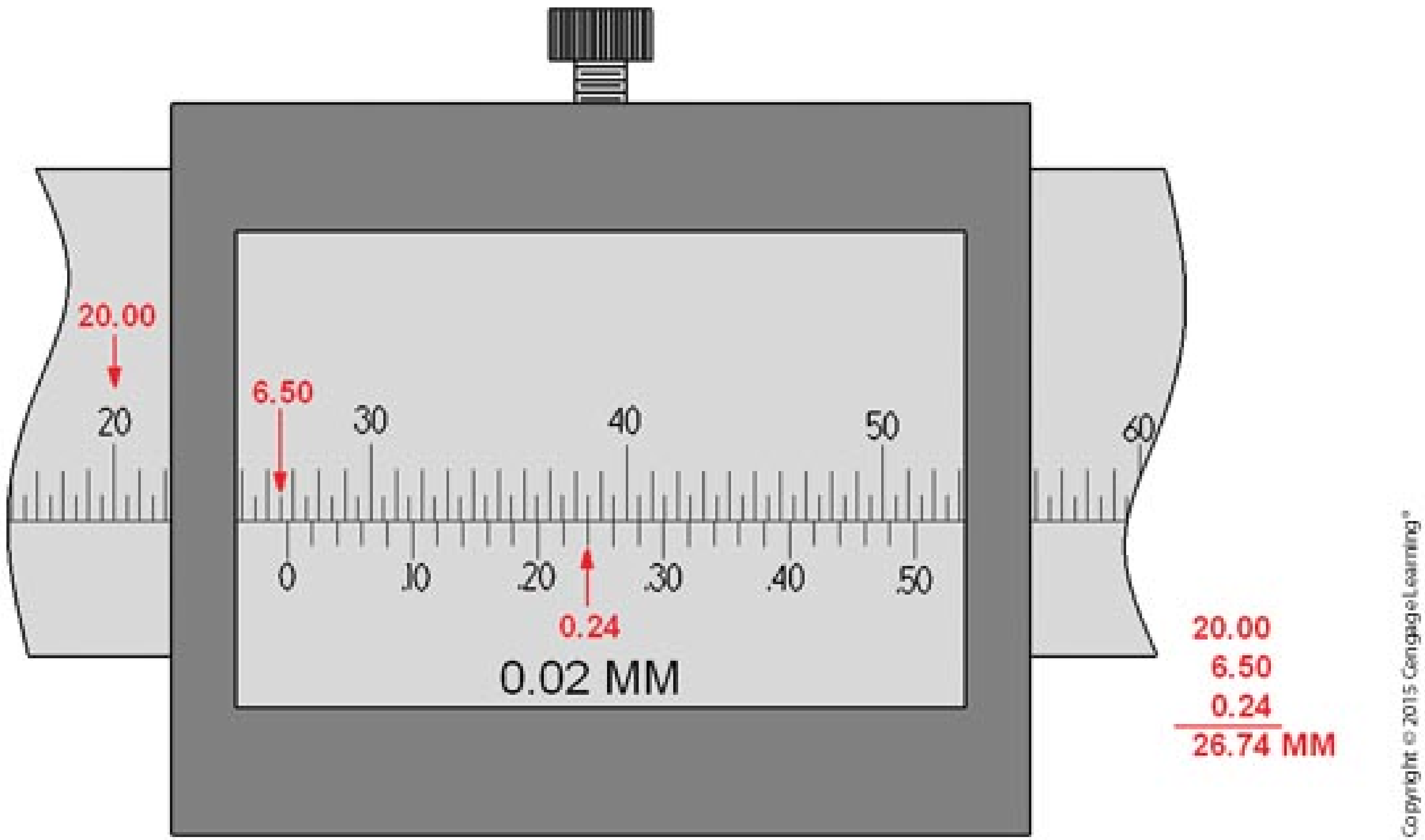


FIGURE 2.4.41 A sample reading using a 25-part metric vernier scale.

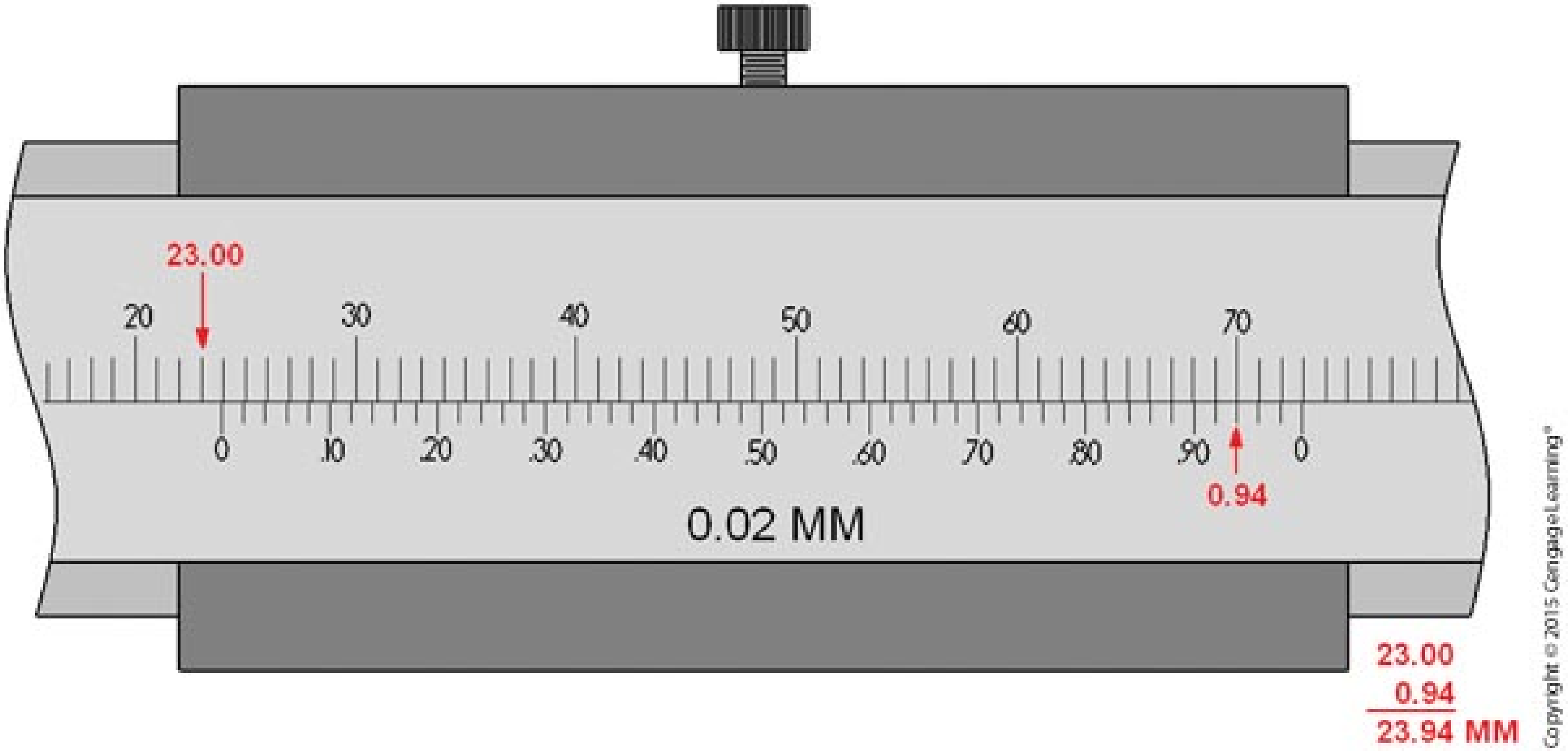
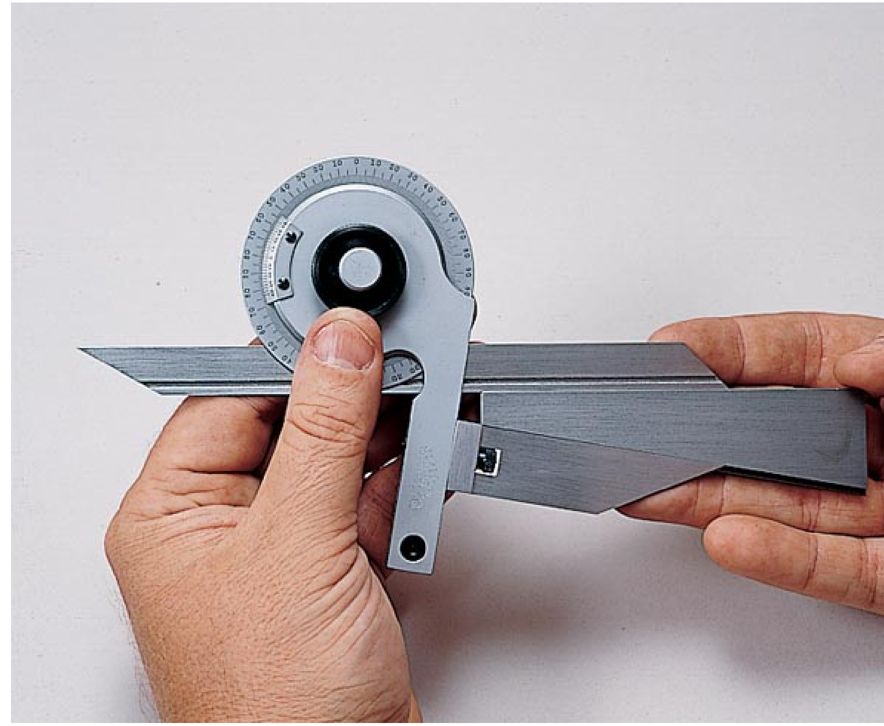


FIGURE 2.4.43 A sample reading using a 50-part metric vernier scale.

Courtesy The L.S. Starrett Company



Courtesy The L.S. Starrett Company

FIGURE 2.4.44 Some uses of the vernier protractor.

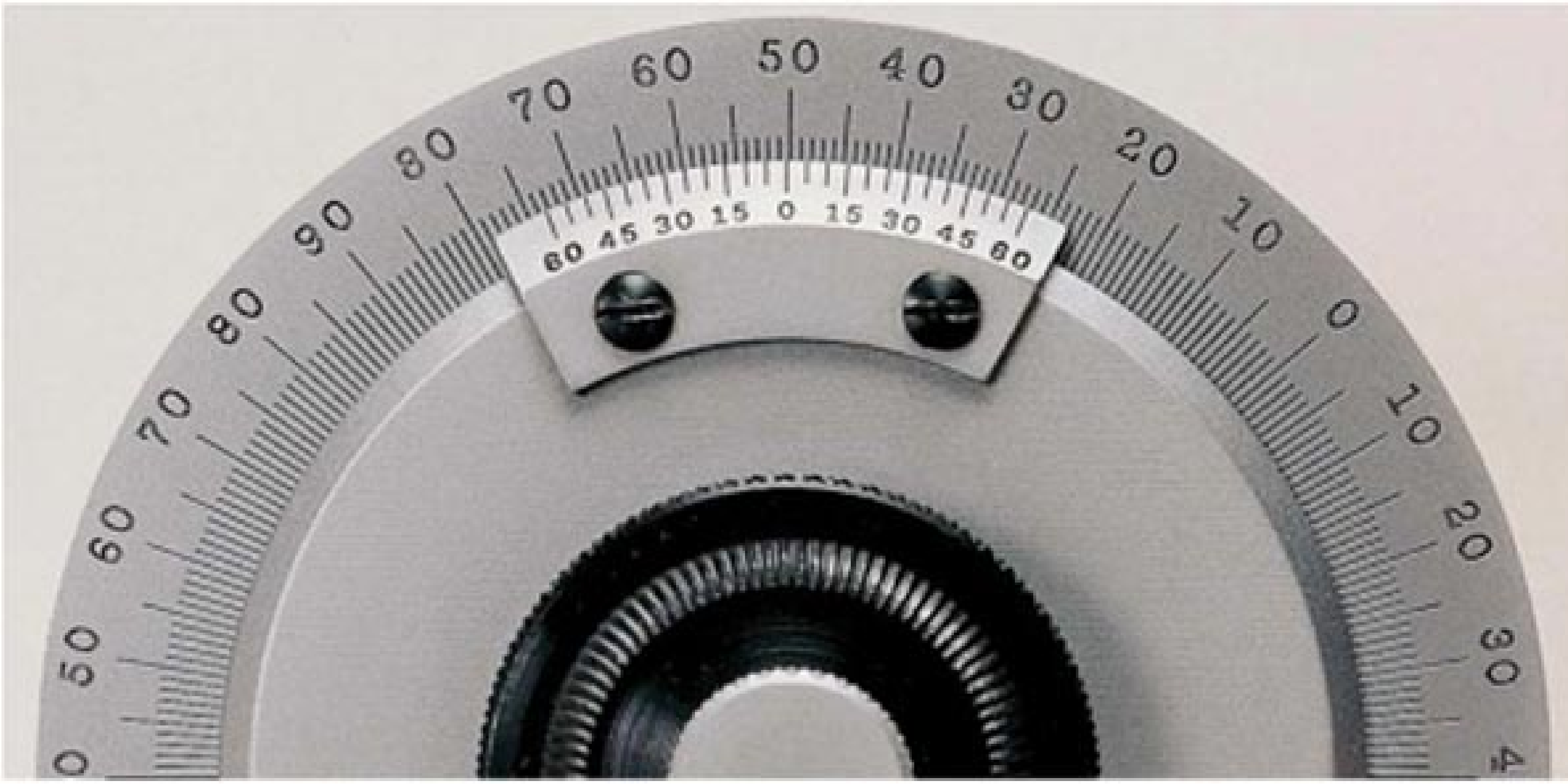
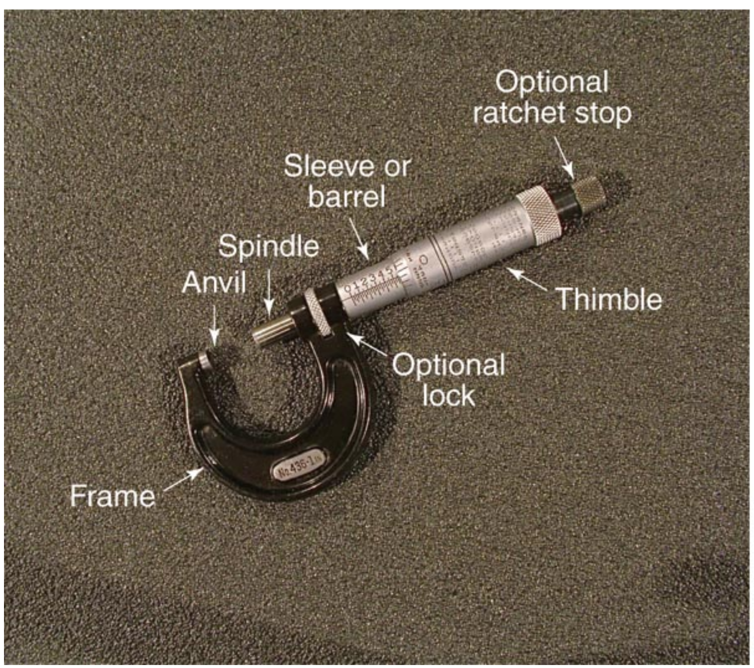


FIGURE 2.4.45 A sample vernier protractor reading. The whole degree reading is 50. Since the degree graduations are increasing moving to the left, read the left side of the vernier scale. The 20-minute graduation aligns, so the full reading is 50 degrees, 20 minutes (50˚ 20’).

Micrometers

- Use very accurate screw thread to measure
  - Types include outside micrometer calipers, inside micrometers, and depth micrometers



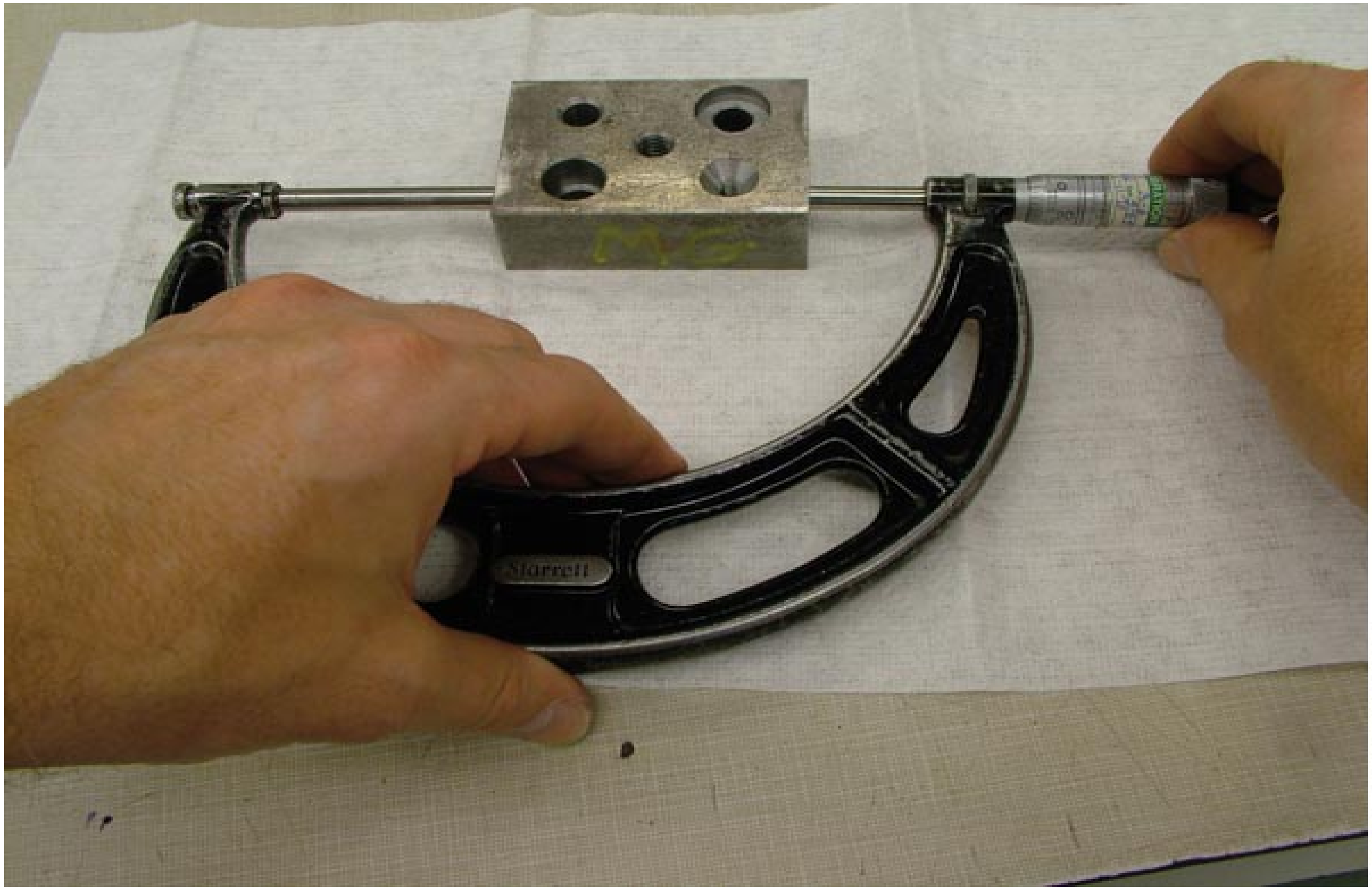


FIGURE 2.4.49 Measuring with a micrometer with a range of 3–4". Gently pivot the micrometer while turning the thimble so that the anvil and spindle become parallel with part surfaces.

FIGURE 2.4.50 A micrometer with interchangeable anvils that can measure from 6–12" with one frame size.

FIGURE 2.4.51 A multiple-anvil micrometer with the flat and rod anvils.

A disc micrometer

A blade micrometer

A conical micrometer

Courtesy The L.S. Starrett Company

A V-anvil micrometer.

Micrometers (cont'd.)

- Outside micrometer caliper
  - Measure external dimensions
  - Inch versions and metric versions all read in the same way
  - Calibration should be performed periodically
- Inside micrometers
  - Used to measure internal dimensions
- Depth Micrometers

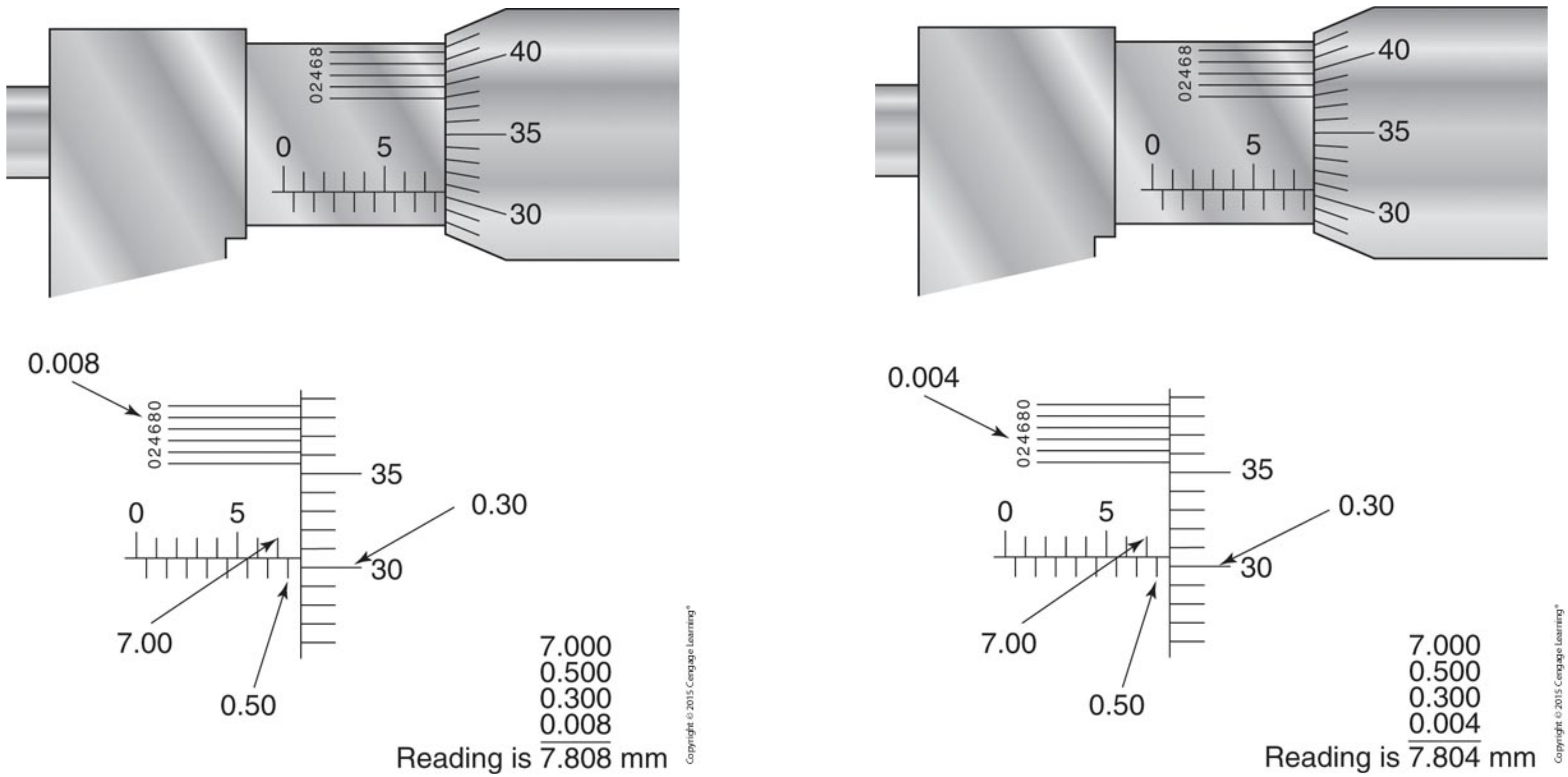


FIGURE 2.4.61 How to read a metric micrometer with a vernier scale to 0.002 mm. The reading is first taken just like with a plain micrometer. Then the vernier reading is added.

FIGURE 2.4.65 (A) A tubular-style inside micrometer. (B) A rod-style inside micrometer.

FIGURE 2.4.66 Taking a measurement using an inside micrometer.

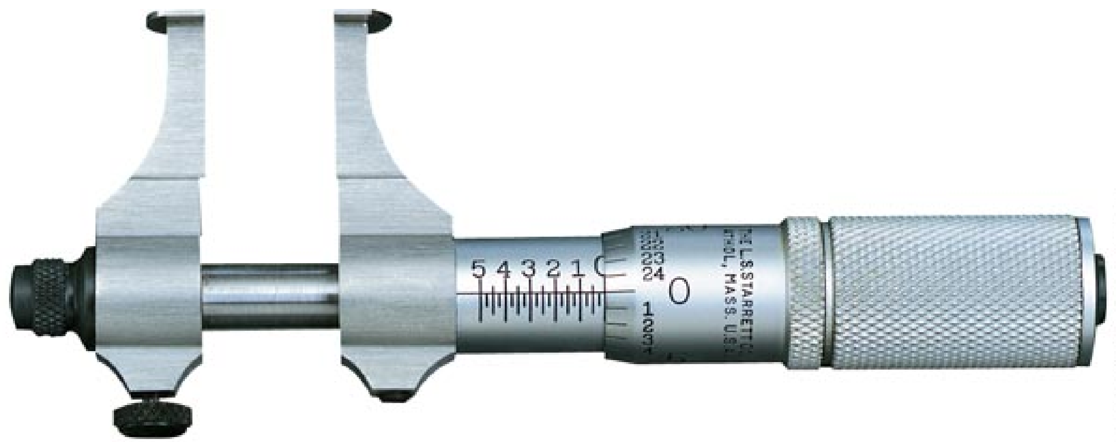


FIGURE 2.4.68 Internal micrometer calipers.

FIGURE 2.4.69 A depth micrometer with rods for different size ranges.

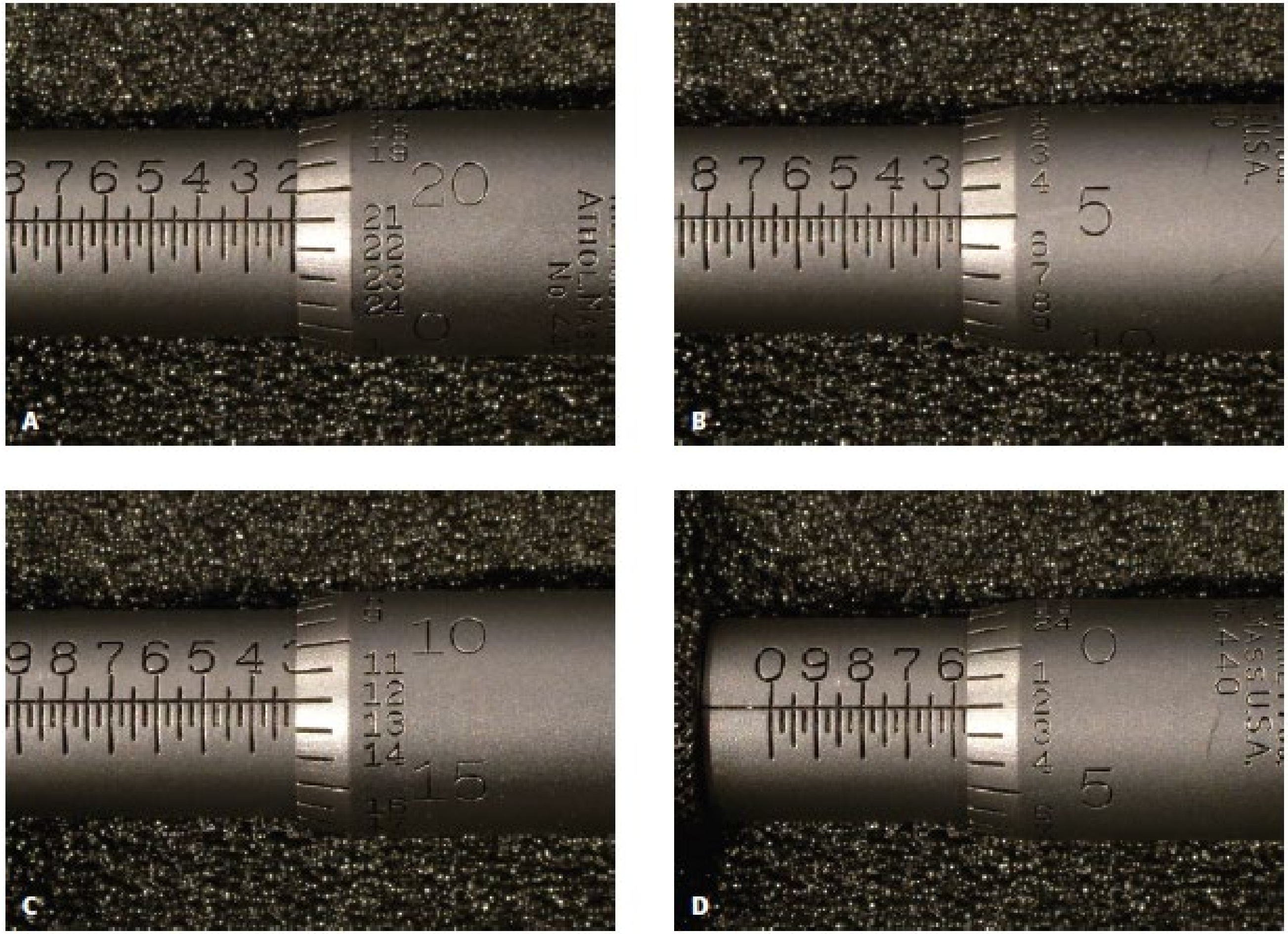
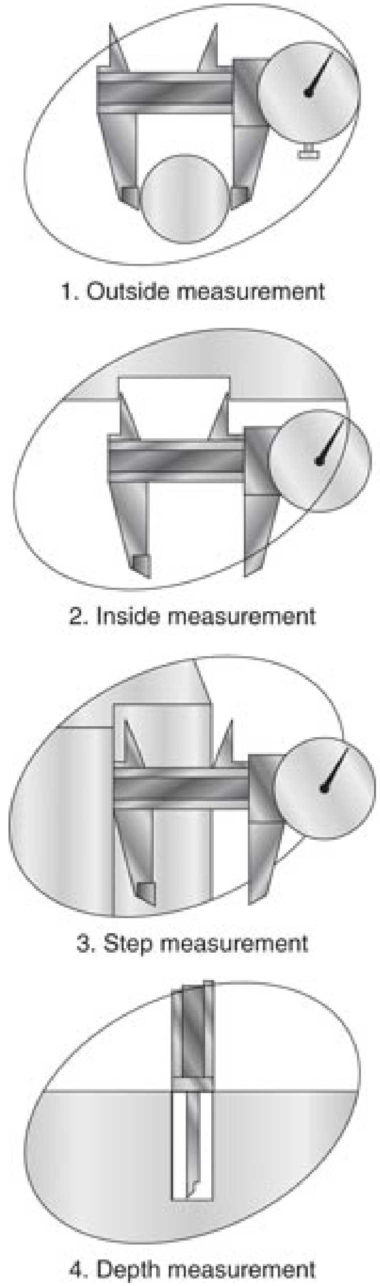


FIGURE 2.4.70 Some sample readings from an inch-based depth micrometer. (A) 0.175 + 0.021 = 0.196"; (B) 0.250 + 0.005 = 0.255"; (C) 0.300 + 0.012 = 0.312"; (D) 0.575 + 0.002 = 0.577".

Dial and Digital Measuring Tools

- Readouts are easier to read
  - Calipers, height, depth, and bore gages
  - Smaller graduations read from the dial
  - Switch between inch and metric by button
  - Battery powered
    - Solar-powered digital calipers

FIGURE 2.4.71 Uses of dial and digital calipers.



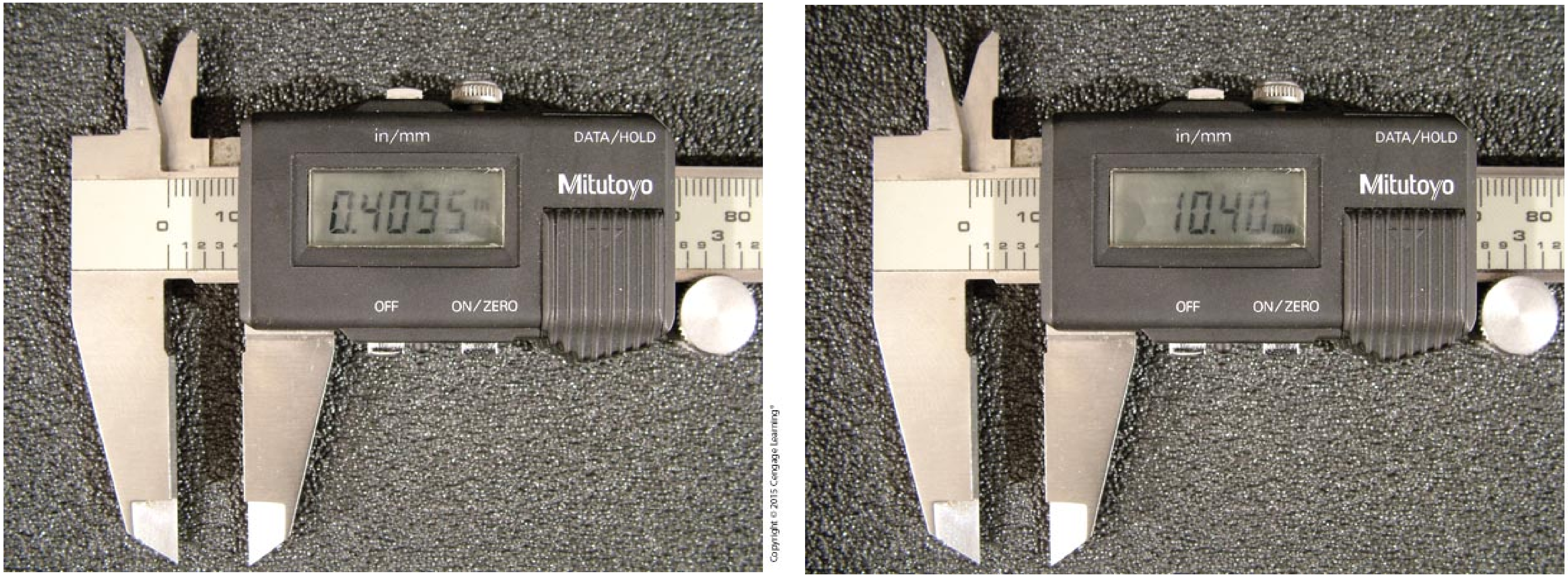
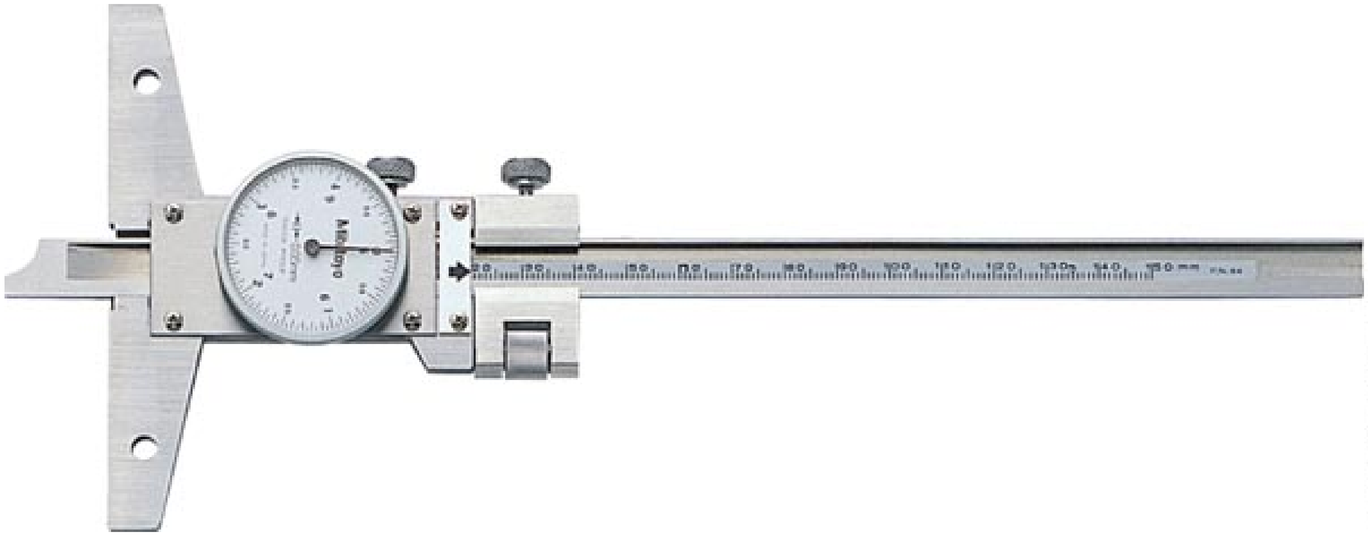


FIGURE 2.4.75 A 0–6" (0–150 mm) digital caliper. Pressing the zero button will set a reference zero at any position. The in/mm button switches the measurement display between inches and millimeters.

A dial height gage

A digital height gage



A dial depth gage

A digital depth gage

A digital bore gage

Courtesy of The L. S. Starrett Company

A dial bore gage

Courtesy of The L. S. Starrett Company

Precision Transfer or Helper-Type Measuring Tools

- Transfer tools lack graduated scales: must be used with other tools
  - Includes small hole gages, telescoping gages, and adjustable parallels
- Dial and digital indicators: tools that show small movements
  - Includes plunge-type and test indicators

FIGURE 2.4.81 Small hole gages are available in (A) full-ball styles. (B) half-ball styles.

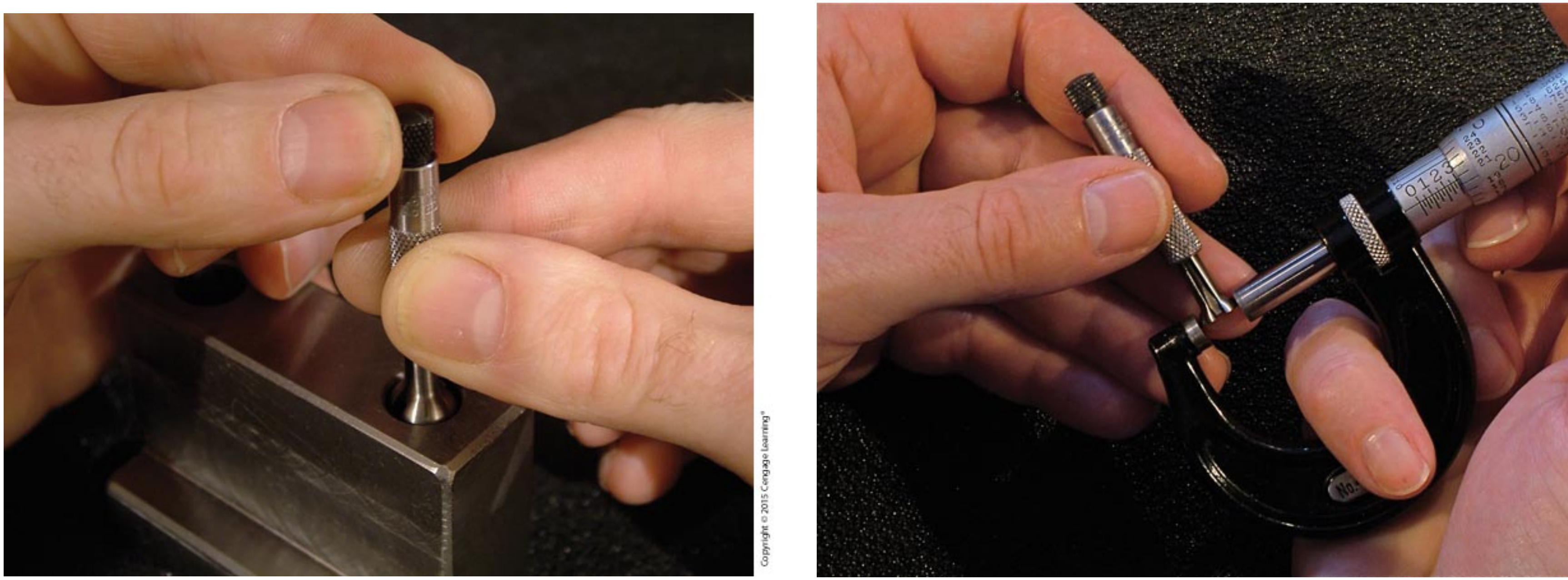


FIGURE 2.4.82 (A) Measuring with a small hole gage. (B) Transferring a small hole gage measurement to a micrometer.

FIGURE 2.4.83 Telescoping gages.

FIGURE 2.4.84 Method for measuring with a telescoping gage.

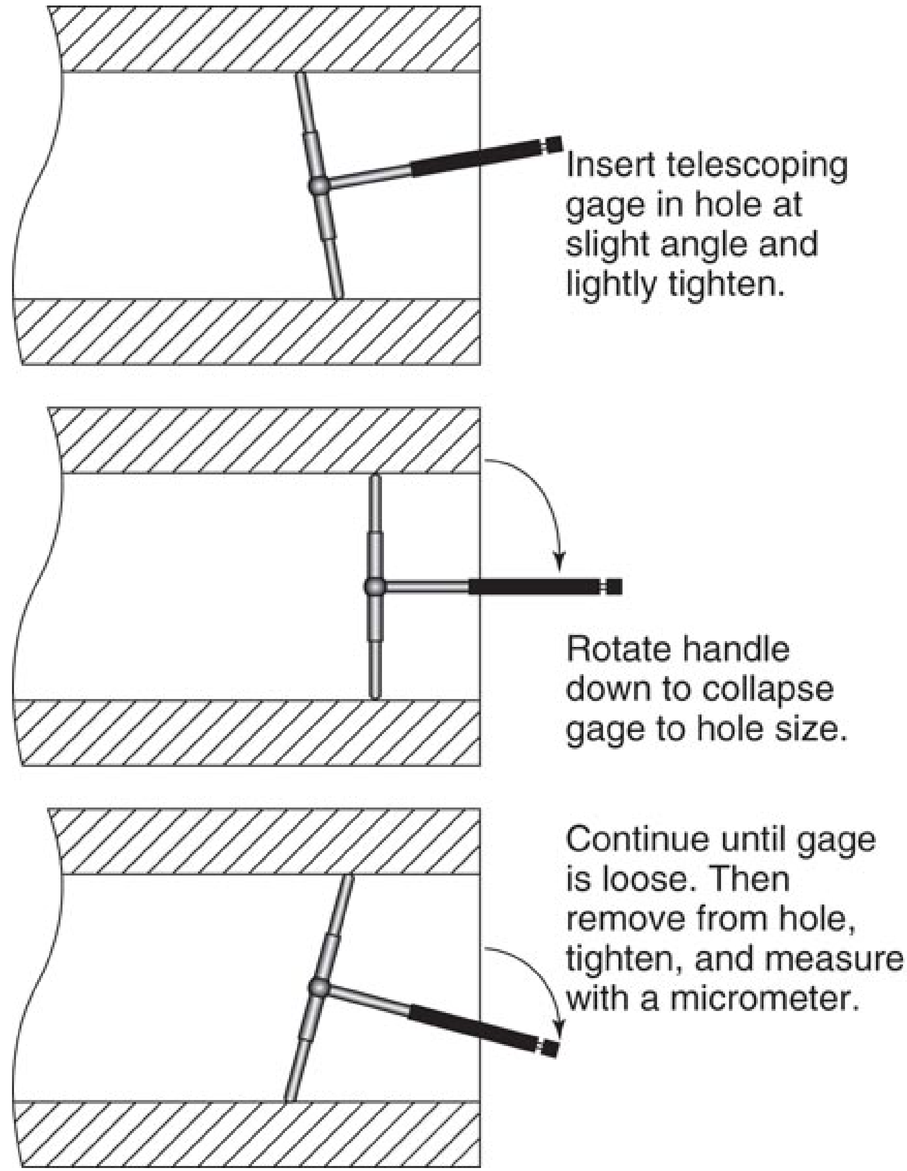
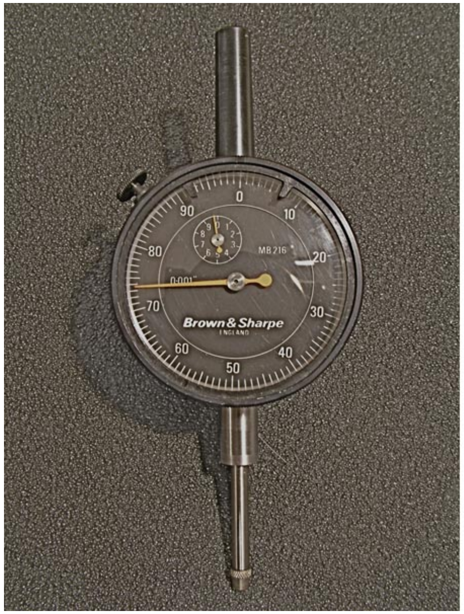


FIGURE 2.4.85 Transferring a telescoping gage measurement to a micrometer.

FIGURE 2.4.86 Measuring a slot width with an adjustable parallel.

Dial and Digital Indicators

- Tools that show small movements
  - Includes plunge-type and test indicators
  - Two designs of dials: balanced and continuous



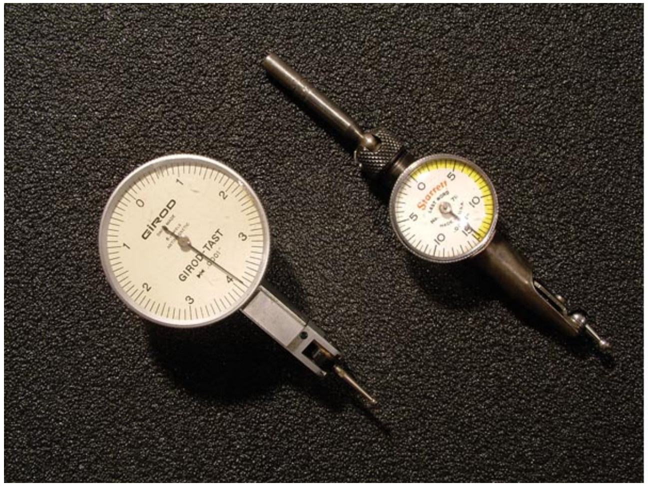


FIGURE 2.4.87 (A) A plunge-type indicator with 0.001" graduations. (B) Test-type indicators with 0.0001" and 0.0005" graduations.

FIGURE 2.4.88 (A) A balanced-type dial indicator face with 0.0005" graduations. (B) A continuous-type dial indicator face with 0.001" graduations. (C) A continuous face with 0.001" graduations and a second set of and numbers. Note the counter-dial on the continuous face dials to keep track of the revolutions of the main needle.

FIGURE 2.4.89 (A) A digital plunge-type indicator. (B) A digital test-type indicator.

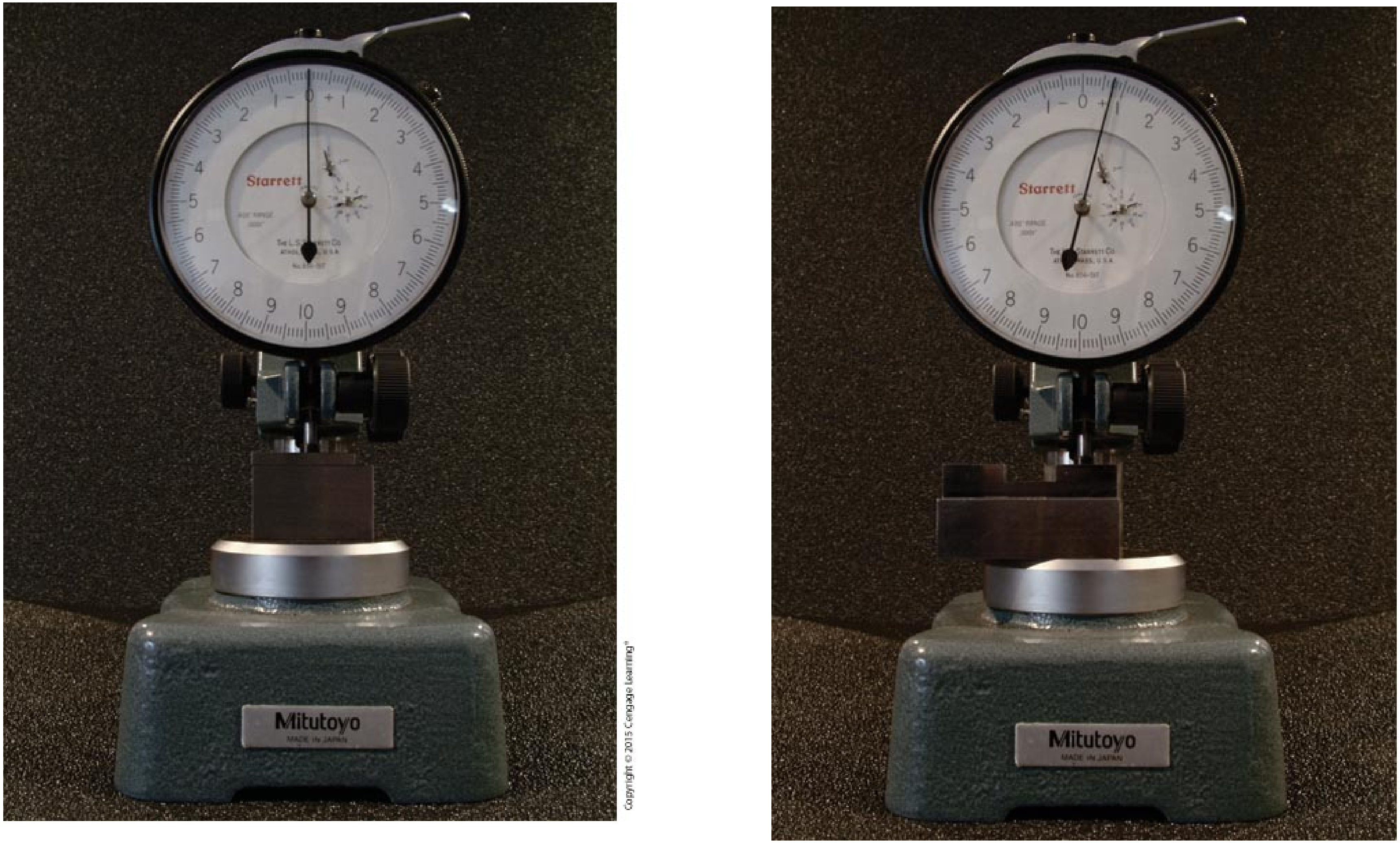


FIGURE 2.4.92 (A) Mastering a dial indicator with a gage block build. (B) Checking a measurement with the drop gage. Note the lever that can be used to raise and lower the indicator contact.

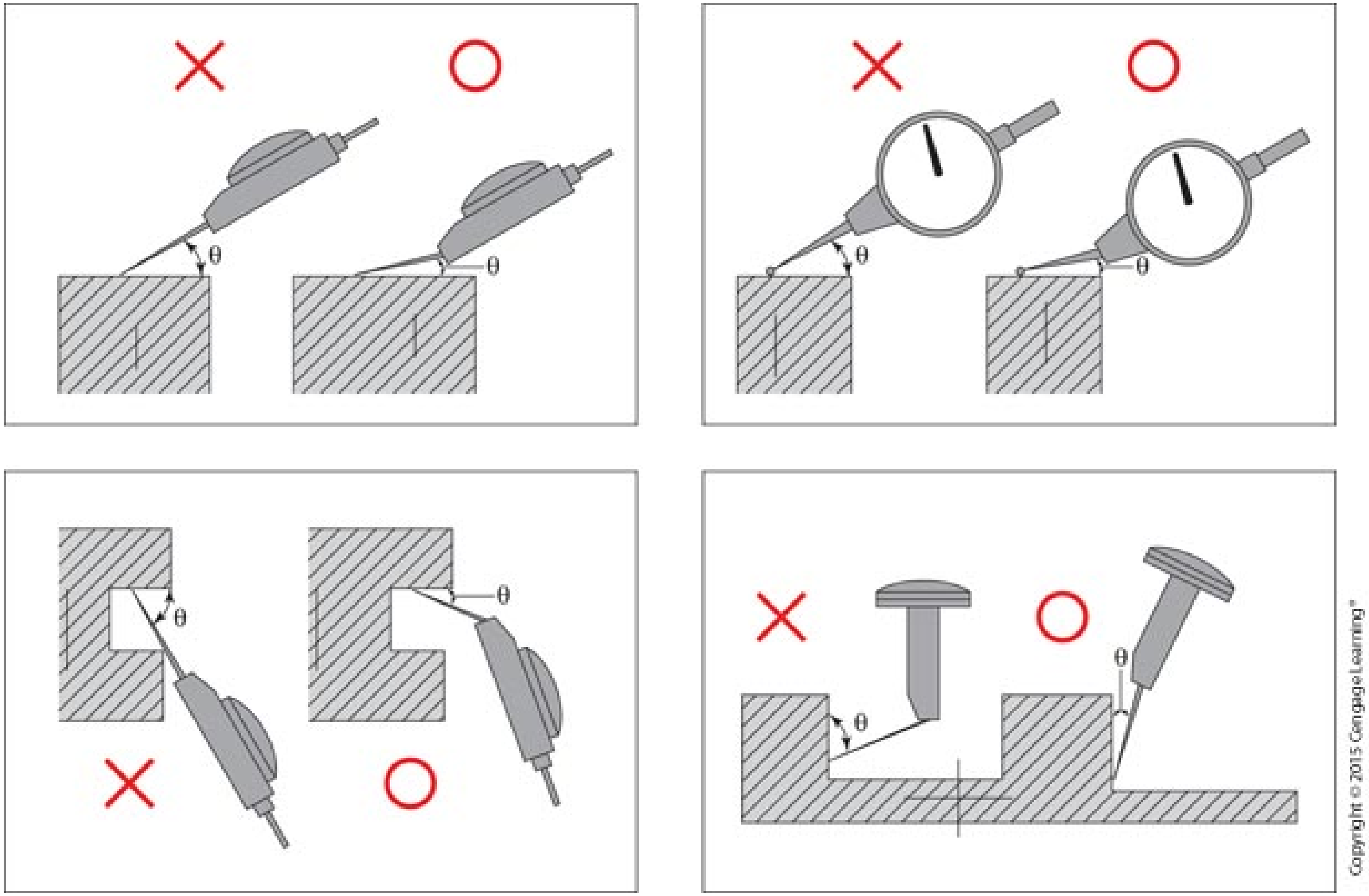


FIGURE 2.4.93 Correct (O) and incorrect (X) settings of test indicator contact points. A small angle between the contact and the work will minimize errors and create more accurate readings.

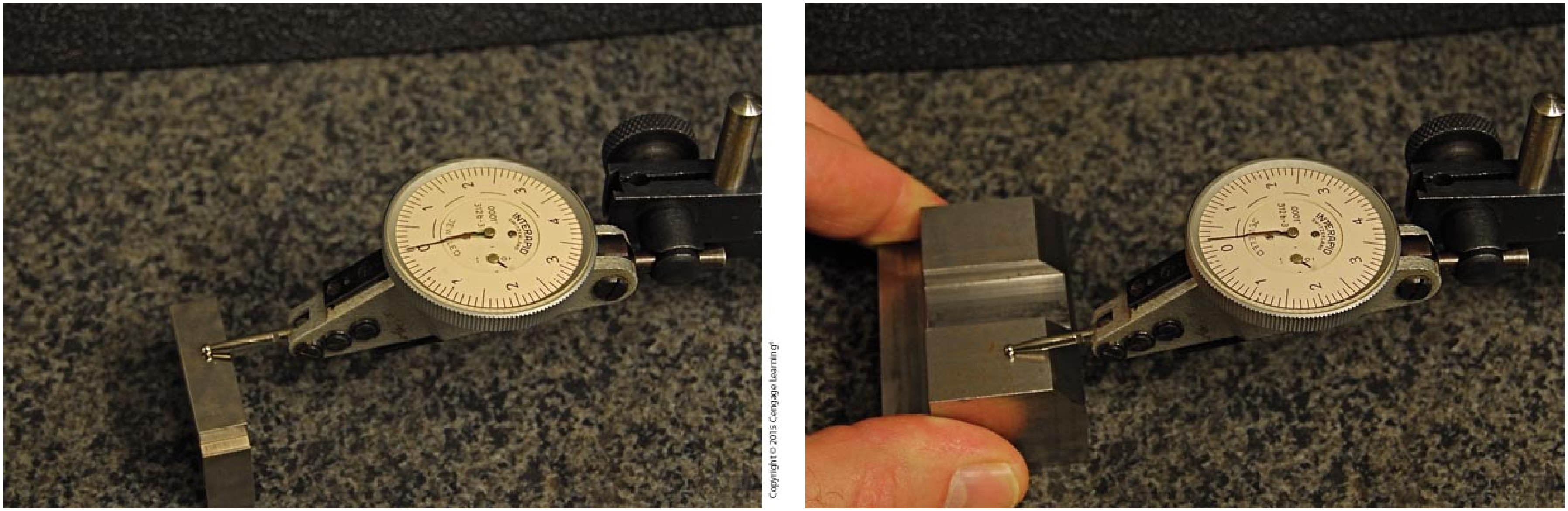


FIGURE 2.4.94 A height-gage-mounted test indicator can be used for comparison measurements after mastering with a gage block build.

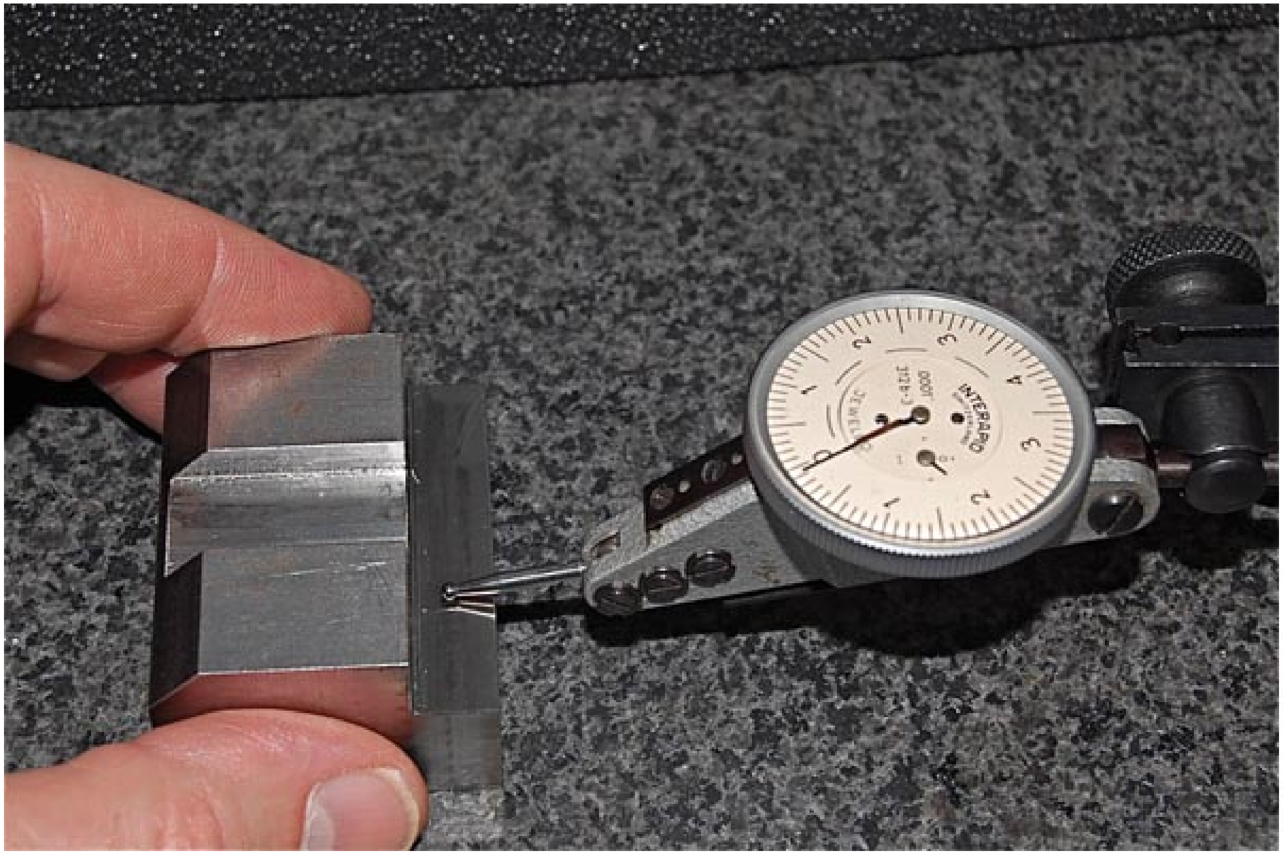


FIGURE 2.4.95 Using a height-gage-mounted test indicator to check for parallelism errors by sliding a part beneath the indicator.

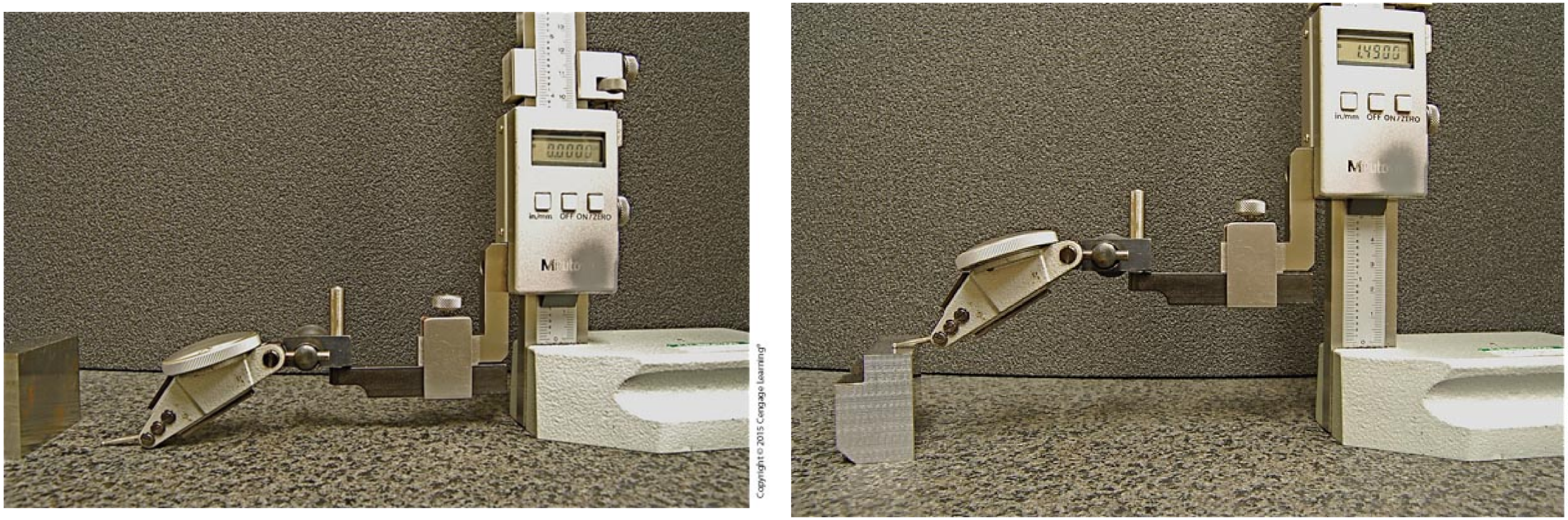


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FIGURE 2.4.96 To avoid measurement errors from varying contact pressure, use a test indicator in place of the standard height gage pointer. (A) Adjust the height gage to bring the indicator in contact with the surface plate to pre-load the indicator. Then zero the indicator and the height gage. (B) To take a measurement, adjust the height gage until the indicator reaches the same zero indicator reading when contacting the surface of the part and record the measurement from the height gage.

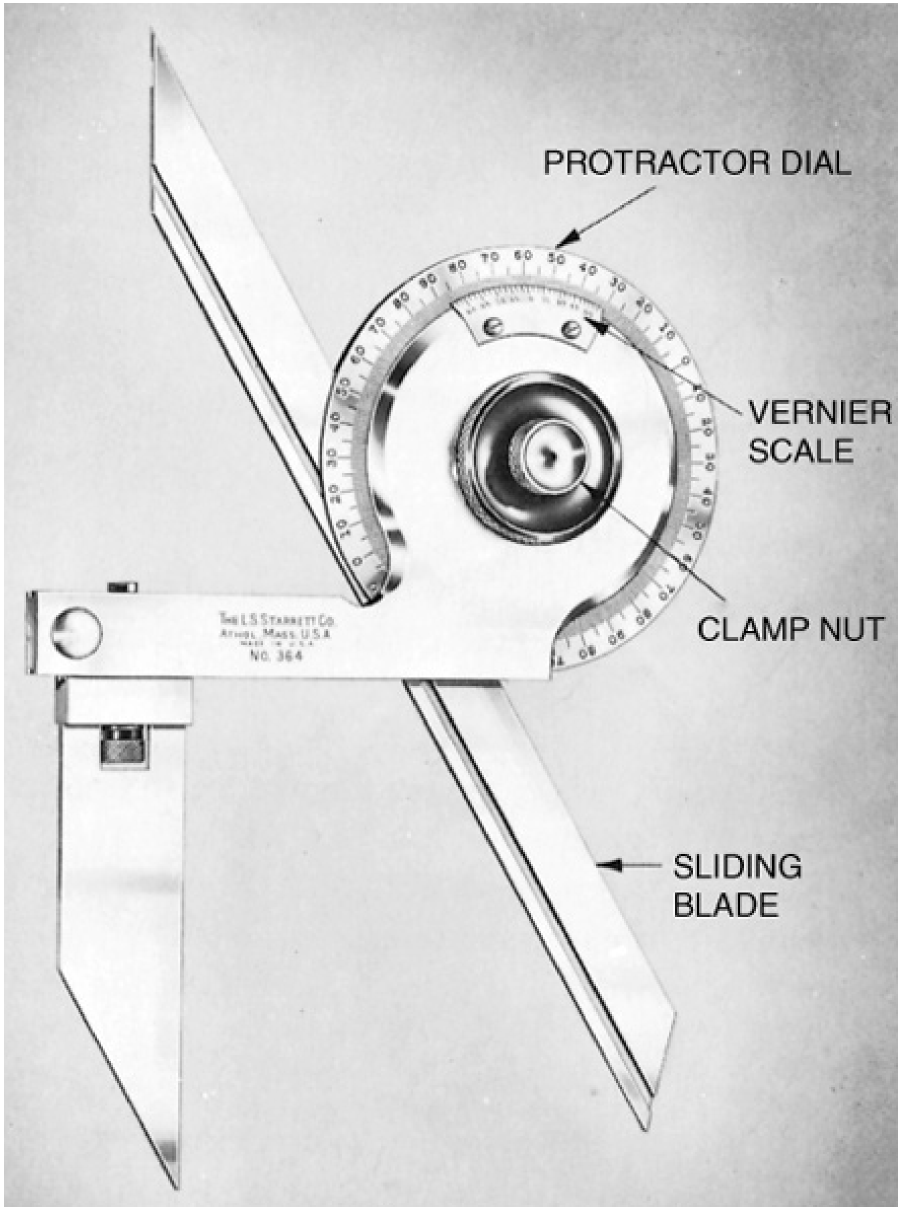
Angular Measurement

Objectives

- Make angular measurements to an accuracy of 5' (minutes) of a degree using a universal bevel protractor
- Make angular measurements to less than 5' of a degree using a sine bar, gage blocks, and a dial indicator

Angular Measurement

- Important phase of machine shop work
- Most common tools
  - Universal bevel protractor
  - Sine bar
  - Sine plate

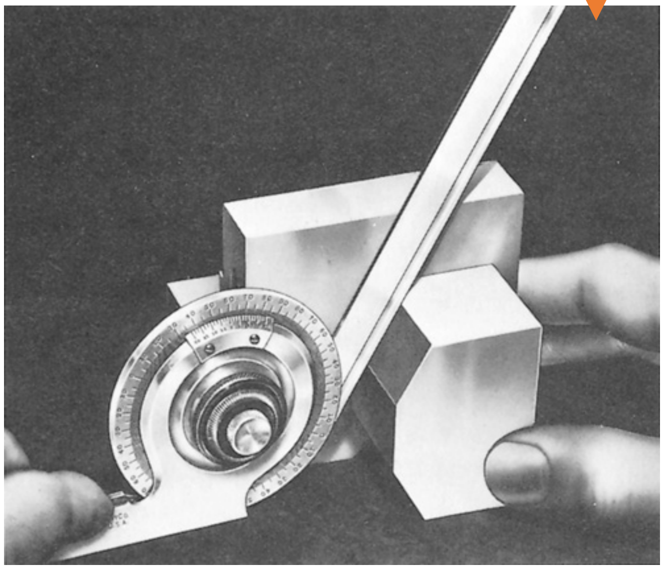


Universal Bevel Protractor

- Precision angles to within 5' (0.083º)
- Consist of base
  - Vernier scale
  - Protractor dial
  - Sliding blade
  - Dial clamp nut

Vernier Protractor

- Used to measure obtuse angle (90º-180º)
- Acute-angle attachment fastened to protractor to measure angles less than 90º
- Main scale divided into two arcs of 180º
  - Scale divided into 12 spaces on each side of 0
  - If zero on vernier scale coincides with line on main: reading in degrees



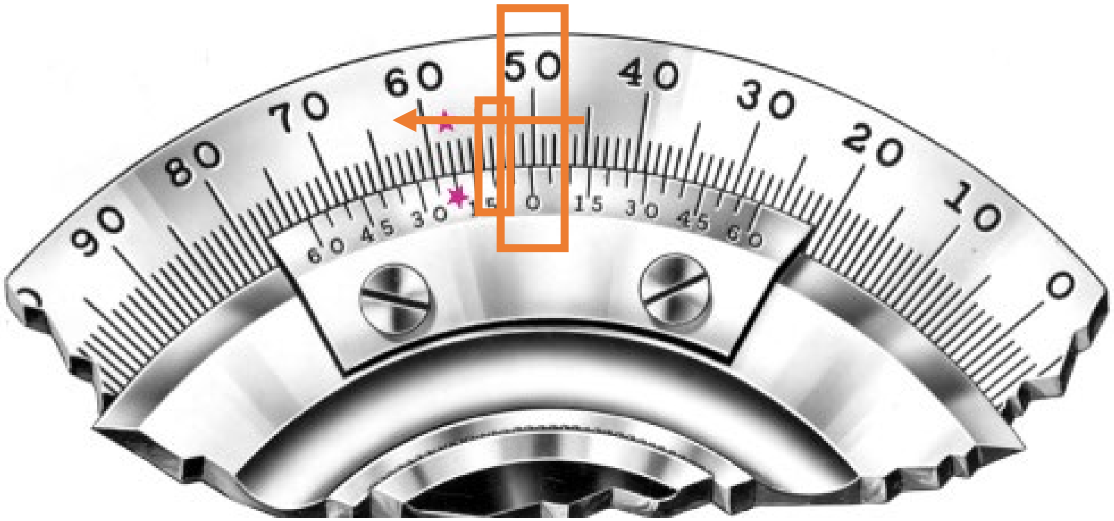
Reading a Vernier Protractor

- Note number of whole degrees between zero on main scale and zero on vernier scale
- Proceeding in same direction, note which vernier line coincides with mail scale line **Fourth**
  - Multiply number by 5' and add to degrees on protractor dial

50º

4 x 5'= 20'

Reading = 50º 20'



Sine Bars

- Used when accuracy of angle must be checked to less than
- Consists of steel bar with two cylinders of equal diameter fastened near ends
  - Centers of cylinders exactly 90º to edge of bar
  - Distance between centers usually 5 or 10 in.
- Made of stabilized tool hardened steel

Sine Bars

- Used on surface plates and any angle by raising one end of bar with gage blocks
- Made 5 in. or in multiples of 5 in.
- Lapped cylinders with 5 in. ±.0002
  or 10 in. ± .00025 between centers
- Face accurate to within .00005 in.
  in 5 inches

Sine Bars

- Hypotenuse of a right-angle triangle
  - Gage block buildup forms side opposite
  - Face of surface plate forms side adjacent

$$\text{Sine of the angle} = \frac{\text{side opposite}}{\text{hypotenuse}}$$

$$= \frac{\text{gage block buildup}}{\text{length of sine bar}} = \frac{\text{buildup}}{5}$$

$$\text{buildup} = 5 \text{ X } \text{sine of required angle}$$

Example

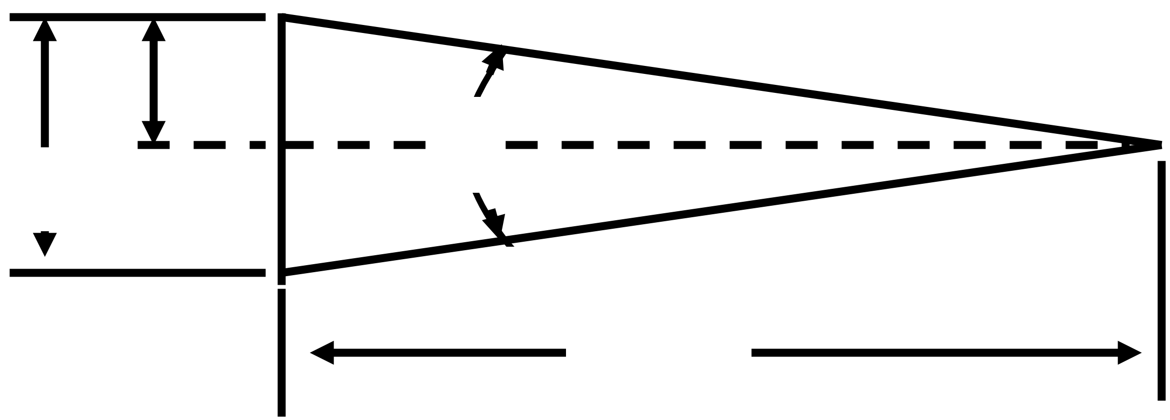
$$\text{buildup} = 5 \ \text{X} \ \text{sine of required angle}$$

Note: This formula applied only to angles up to 60º .

Sine Bars

- Angles > 60º
  - Better to set up work using complement of angle
  - Angle plate turned 90º to produce correct angle
    - When sine bar in near-horizontal position, small change in height of buildup will produce smaller change in angle than near-vertical position
- Small angles
  - Sometimes impossible to get buildup small enough to place under one end of sine bar
    - Place gage blocks under both rolls of sine bar
    - Net difference in measurement equal to required buildup

Sine Bar Used to Check Taper



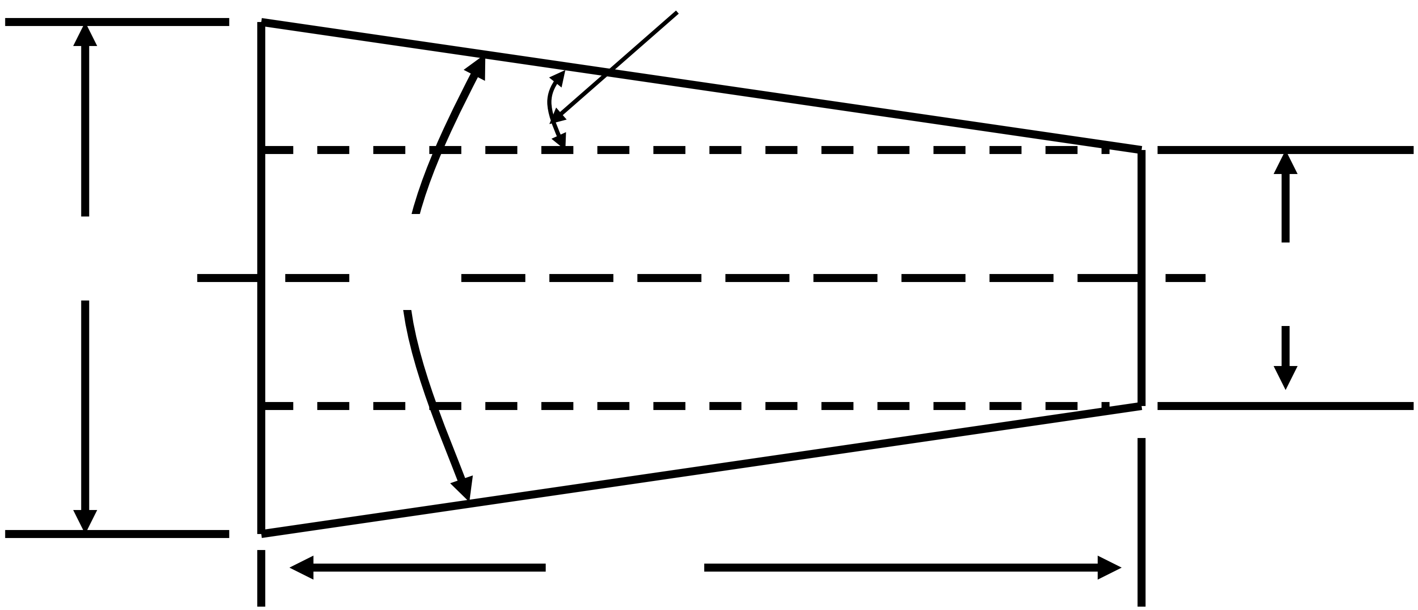
$$Tan\frac{a}{2} = \frac{\frac{1}{2}}{12} = .04166 = 2°46'10''$$

$$\therefore a = 4°46'20''$$

Sine Bar Used to Check Taper (cont.)

$$tpf = \tan\frac{1}{2}a \text{ X } 24$$

Sine Bar Used to Check Taper (cont.)



$$AC = \frac{1.750 - 1.000}{2} = .375$$

$$\tan\frac{a}{2} = \frac{.375}{3.187} = .11766 = 6°42'22'' \quad \therefore a = 13°24'44''$$

$$\text{Buildup} = 5 \sin 13°24'44'' \, .23196)$$

$$= 1.1598 \text{ in.}$$

Tapers

- Metric tapers expressed as ratio of 1 mm per unit of length
  - Ratio of 1:20 means would taper 1 mm in diameter in 20 mm of length
- Can be checked conveniently and accurately with taper micrometer
  - Measures work to sine bar accuracy while work still in machine

Sine Plate

- Based on same principle as sine bar
  - Similar in construction except it is wider
    - Sine bars up to 1 in. wide
    - Sine plates generally more than 2 in. wide
- Several tapped hole in surface
  - Permit work to be clamped to surface of sine plate
- End stop prevents workpiece from moving during machining

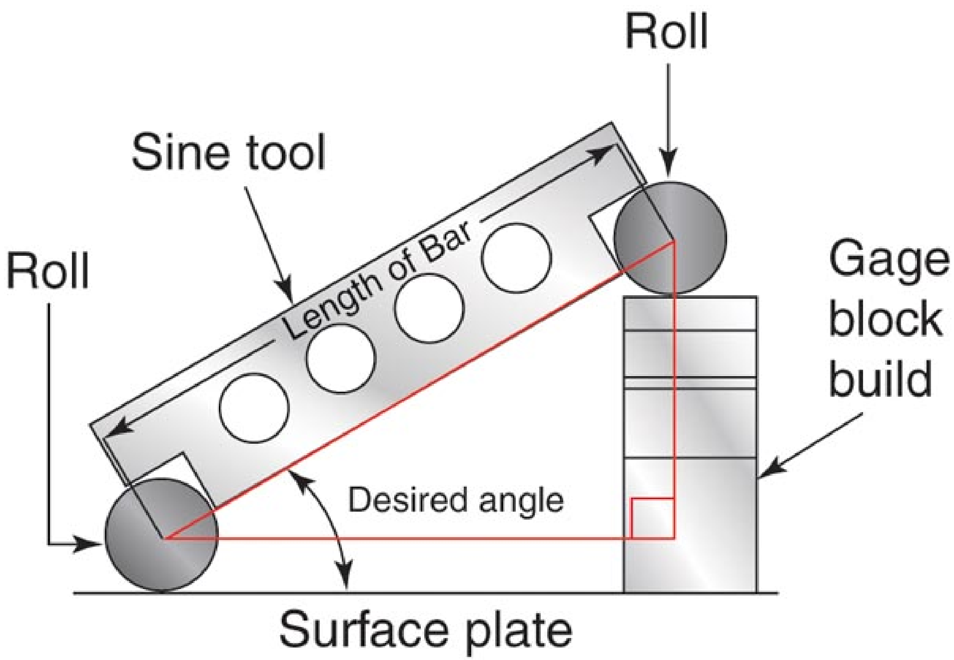
Sine Table

- Sine plate hinged to a base
- Both sine plate and table
  - Supplied in 5 and 10 in. lengths
  - Have step or groove of .100 or .200 deep ground in base to permit buildup for small angles to be placed under free roll

Compound Sine Plate or Table

- Consists of one sine plate superimposed on another sine plate
    - Lower plate hinged to base and may be titled to any angle from 0º to 60º by placing gage blocks under free roll or cylinder
    - Upper base hinged to lower base so that cylinder and hinge are at right angles to lower plate
        - Can be tilted to any angle up to 60º
        - Permits setting of compound angles
- Not used until finishing operation (grinding)

Sine Tools



- Measure angles relative to a reference surface
  - Use two rolls and a known distance
  - Types include bars, blocks, plates, and vises

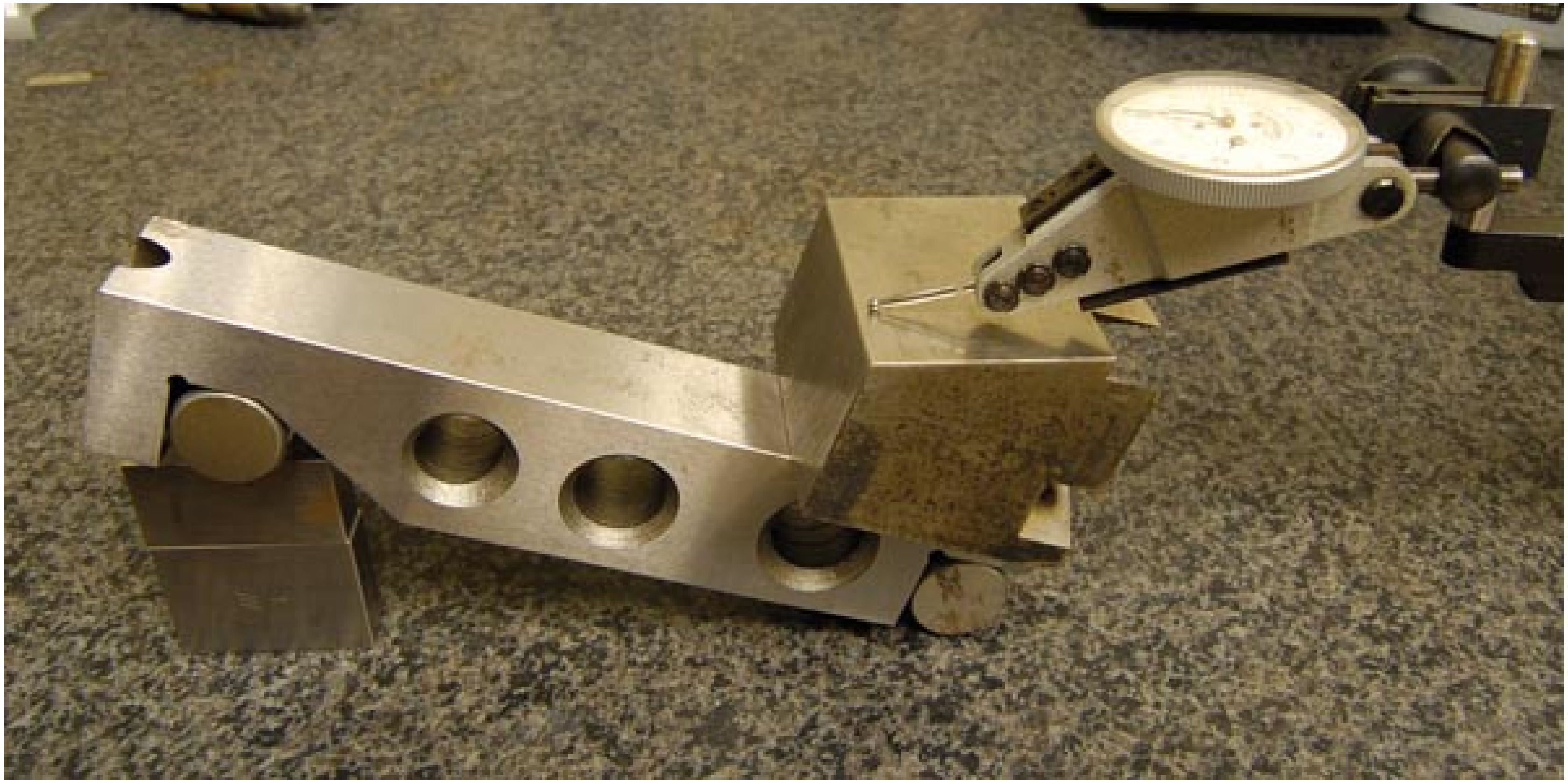
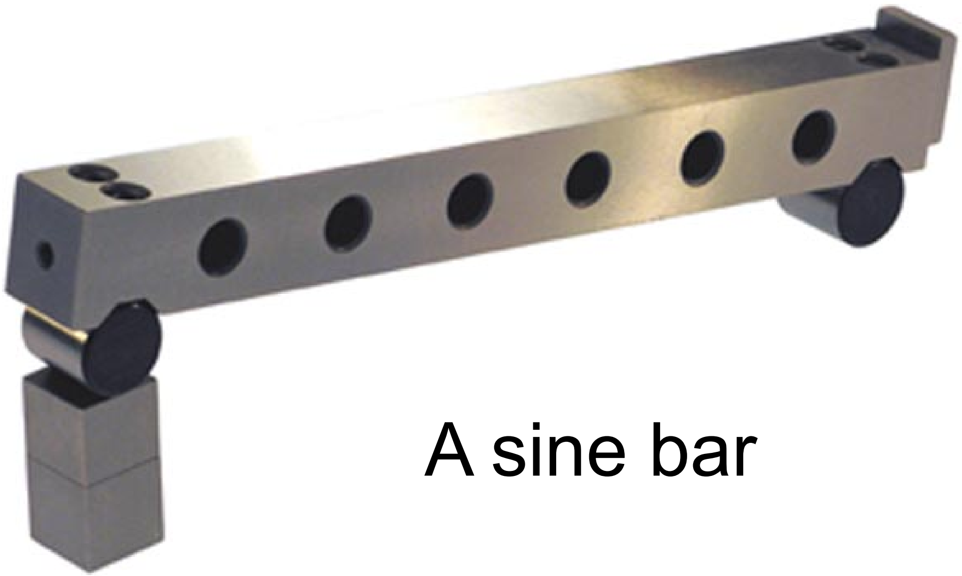
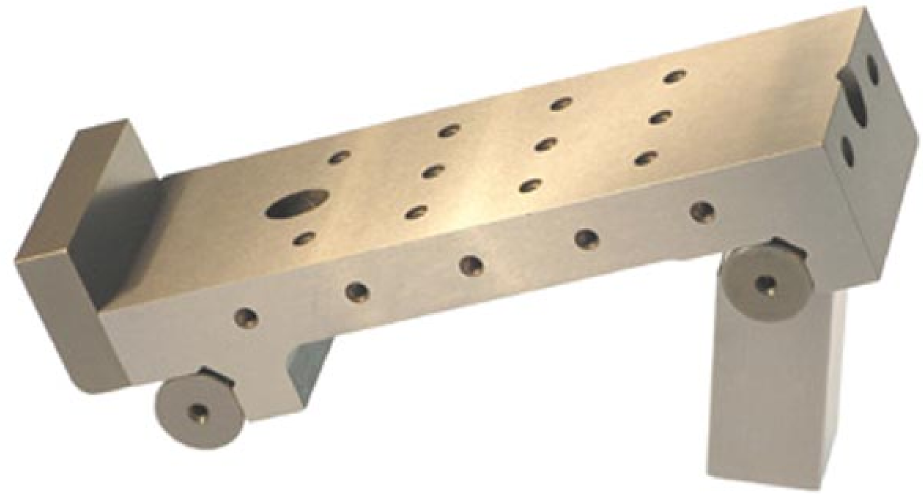


FIGURE 2.4.98 Indicating an angular surface using a sine tool. Note the gage blocks used to raise the one end of the tool.



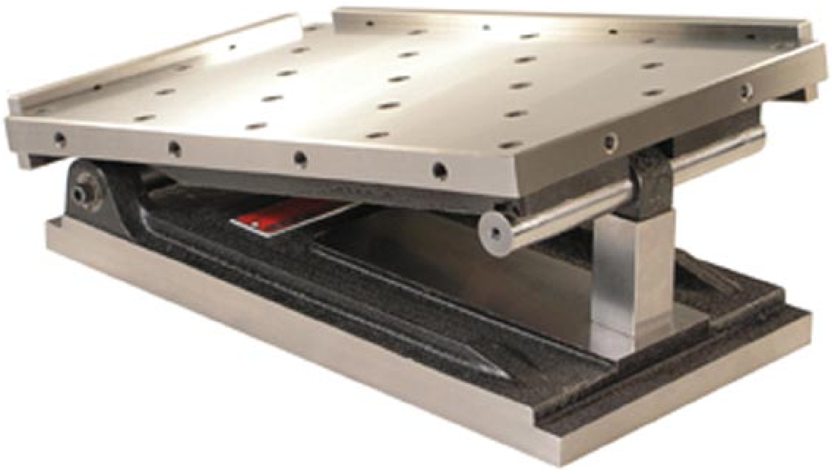
A sine bar

uburban Tool, Inc

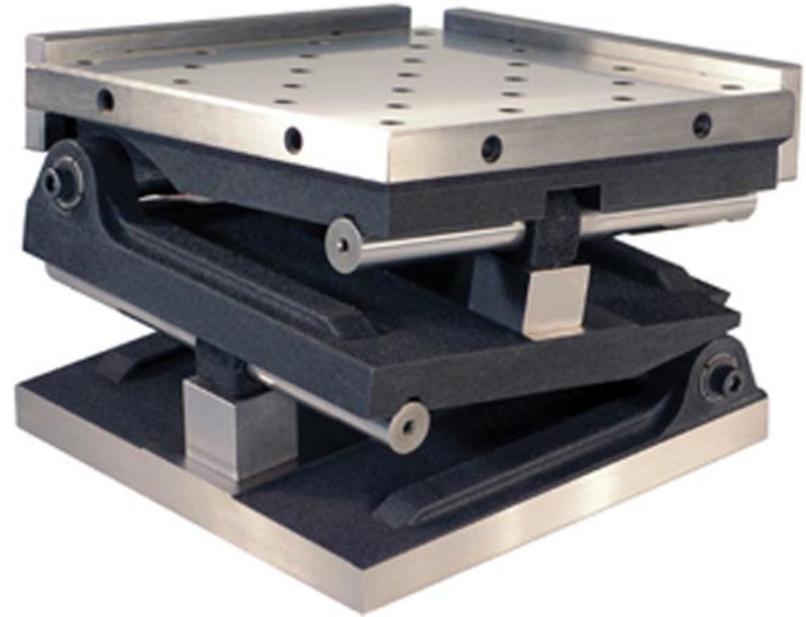


Courtesy of Suburban Tool, Inc

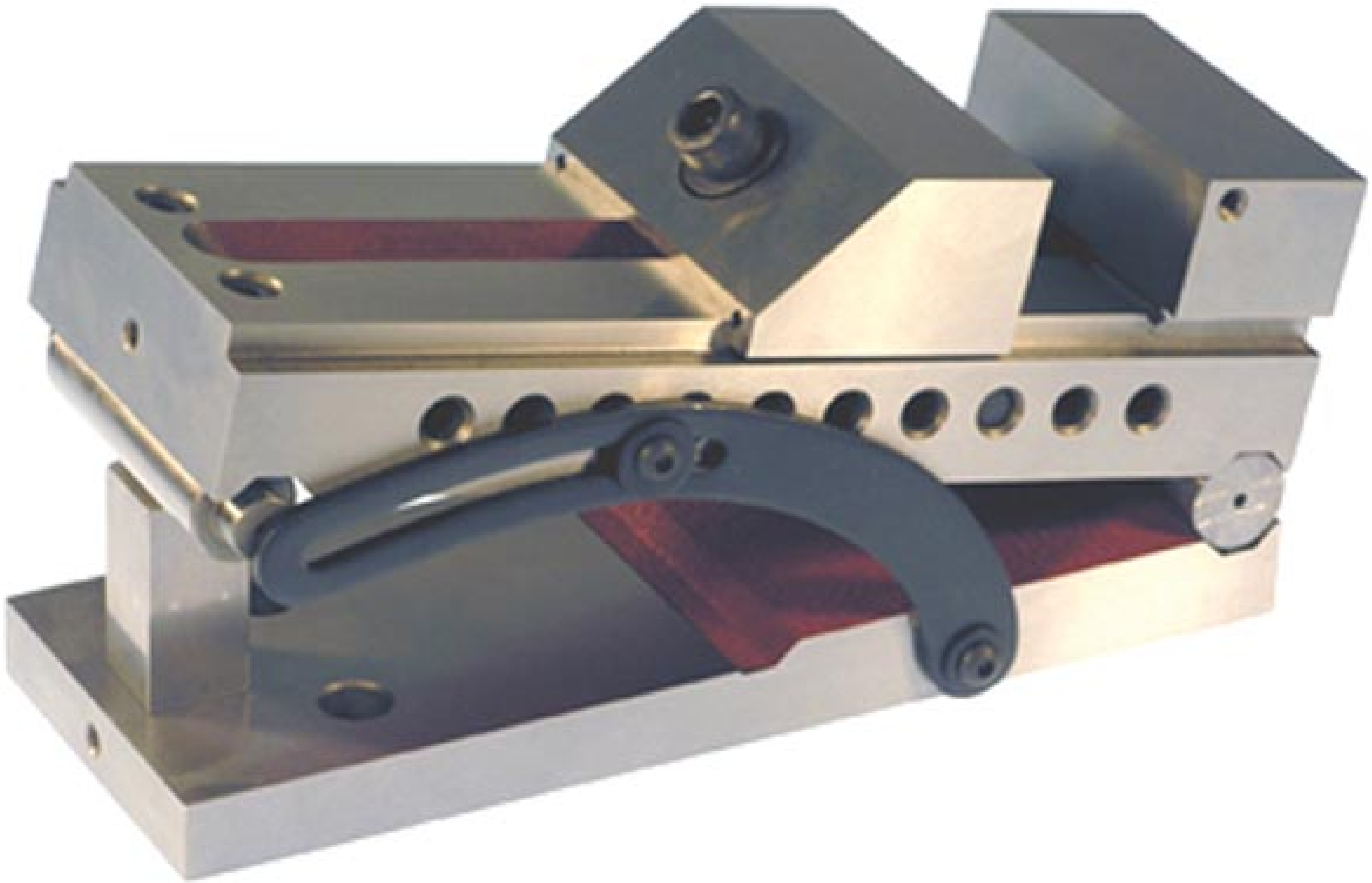
A sine block



A sine plate



A compound sine plate



Courtesy of Suburban Tool, Inc

Sine vise

Surface Finish Measurement

- Finish: surface texture of machined part
  - Roughness: peaks and valleys left by cutting
    - Measured by Ra, in microinches or micrometers
  - Waviness: variation over larger surface
  - Measured by comparator or profilometer

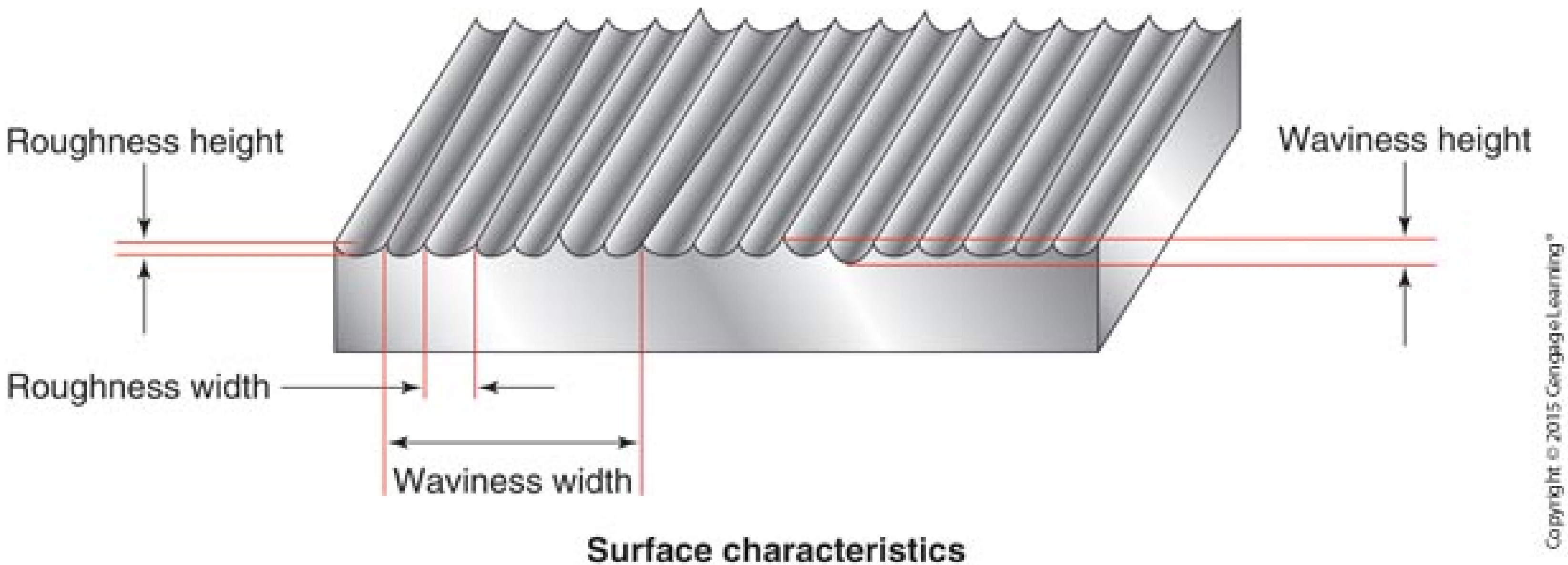


FIGURE 2.4.102 Surface finish roughness and waviness.

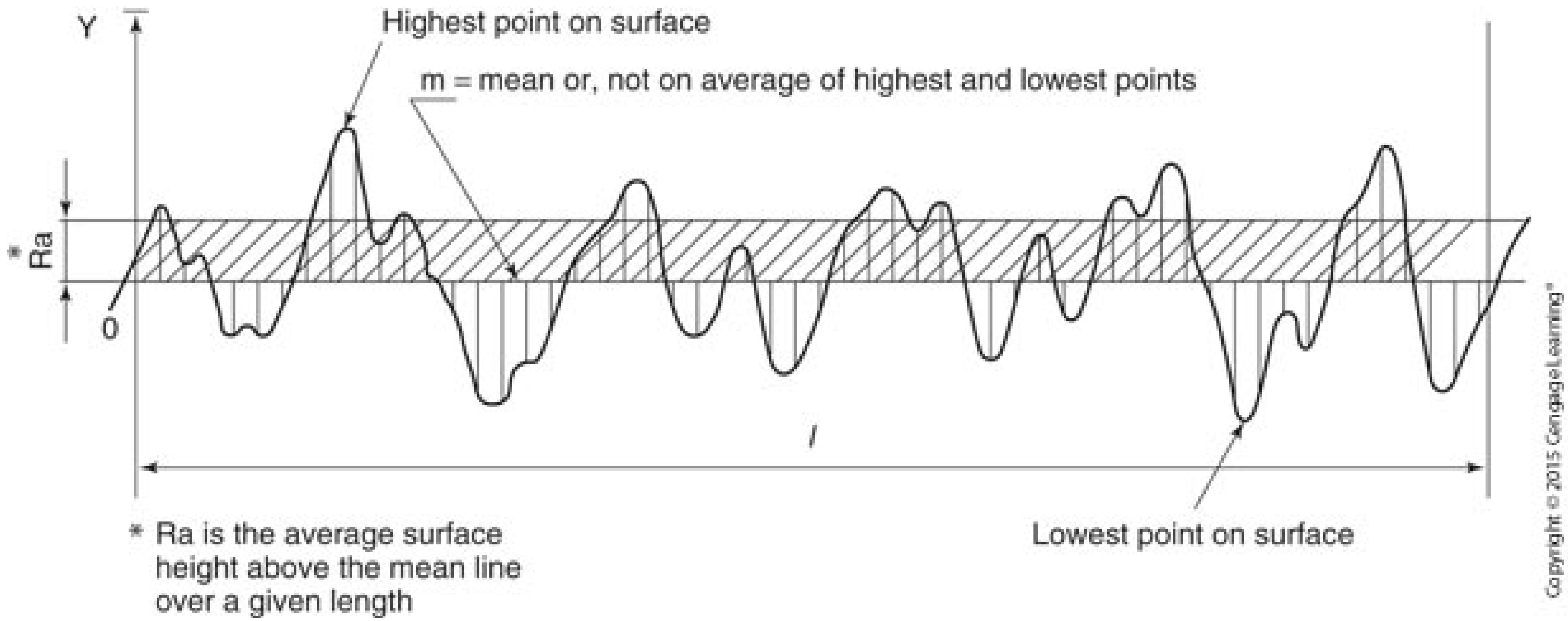


FIGURE 2.4.103 The basic concept of Ra surface finish measurement.

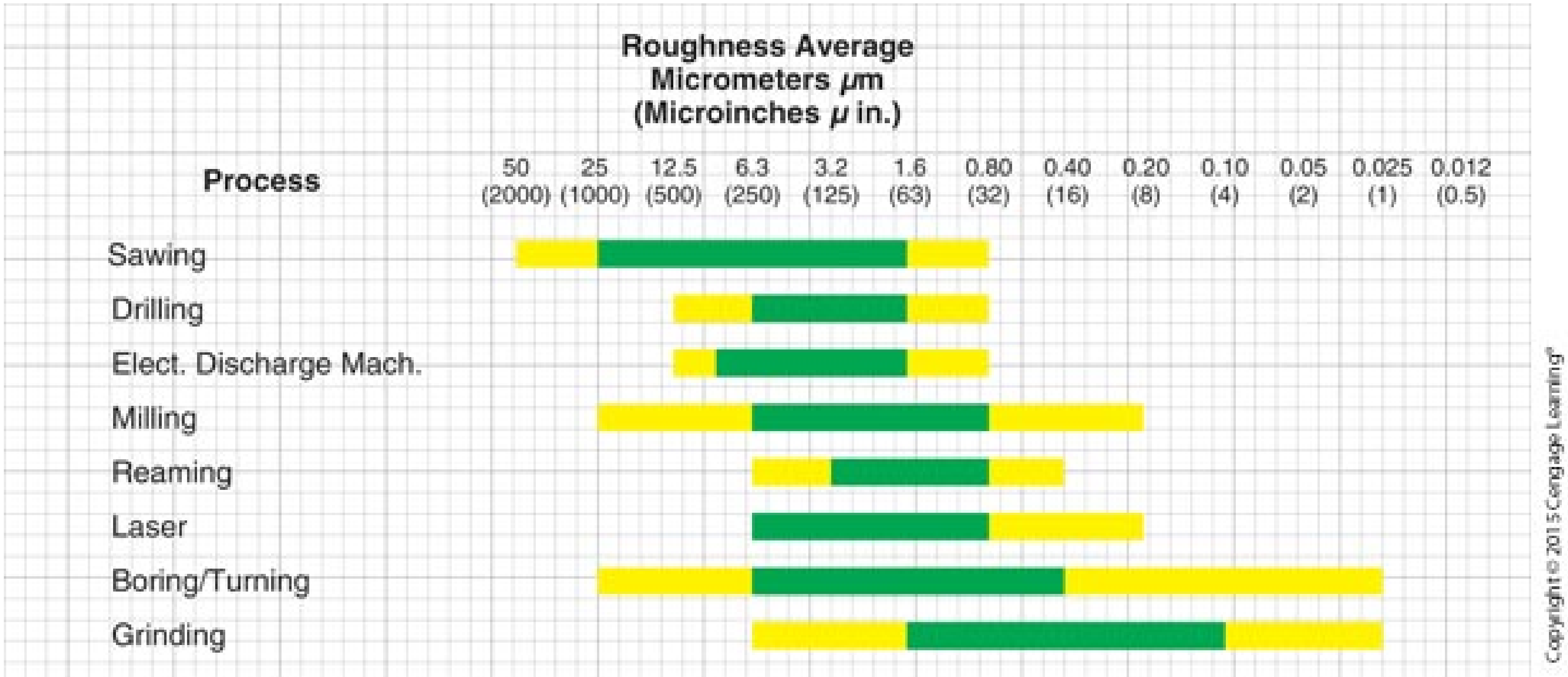


FIGURE 2.4.104 Surface finish ranges produced by various machining operations.

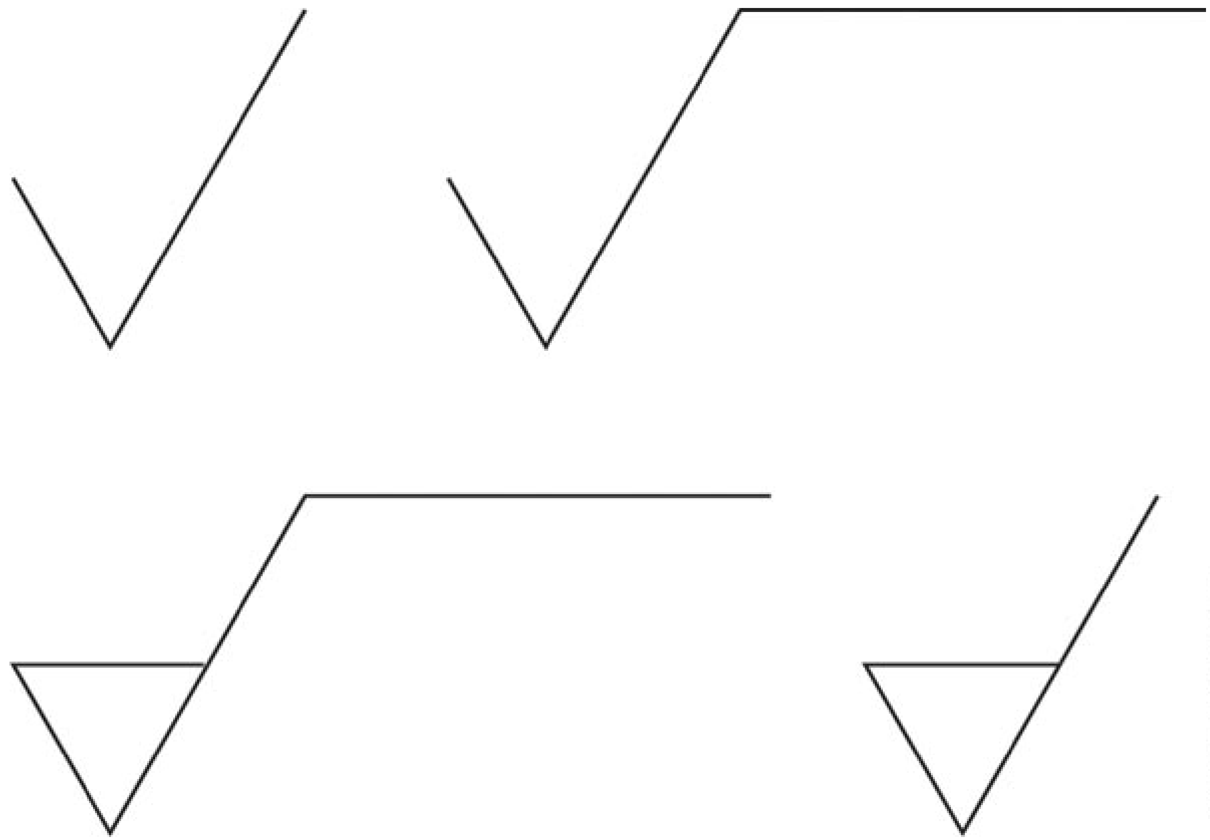


FIGURE 2.4.105 Some of the various types of surface finish symbols that may be encountered in the machining industry.

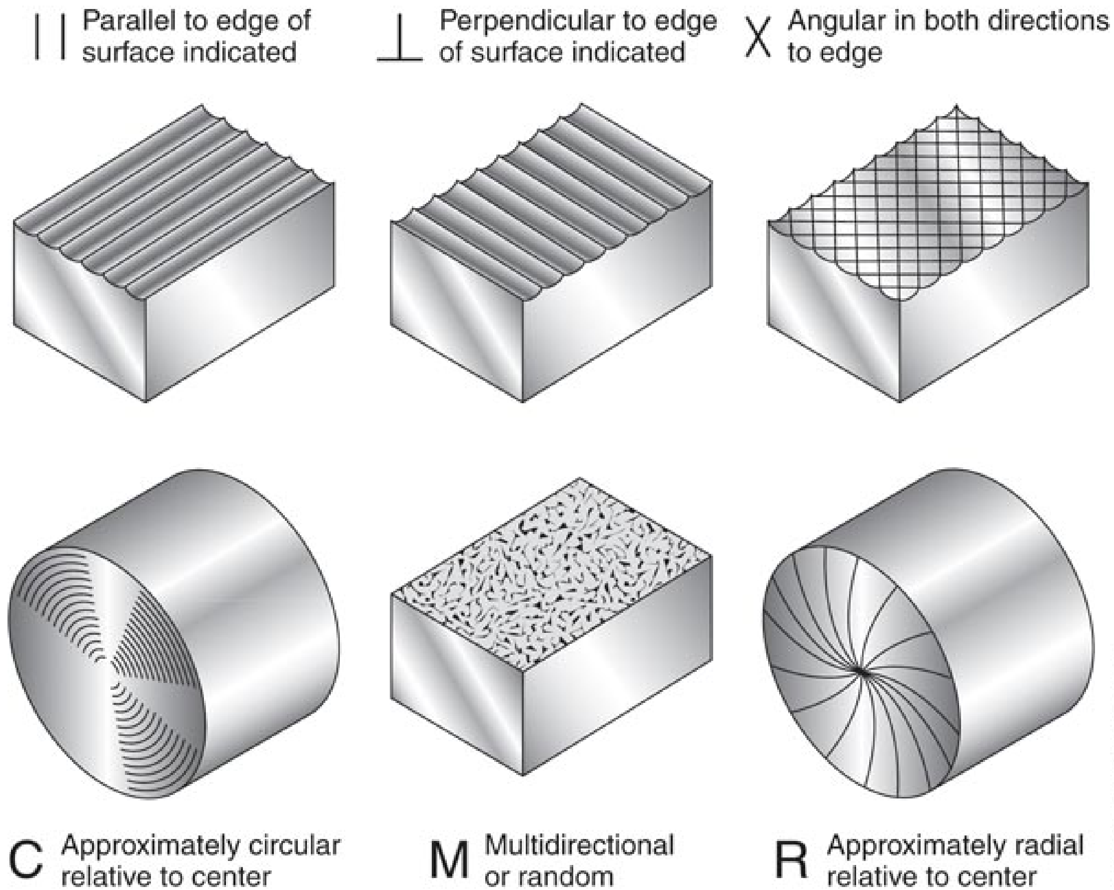


FIGURE 2.4.106 Method for specifying lay patterns with a surface finish symbol.

FIGURE 2.4.107 A surface finish comparator gives examples of machined surfaces at different levels of roughness.

FIGURE 2.4.108 A portable profilometer measuring the surface finish of the hole in a machined component.

Optical Comparators

- Projects magnified image on screen for measurement

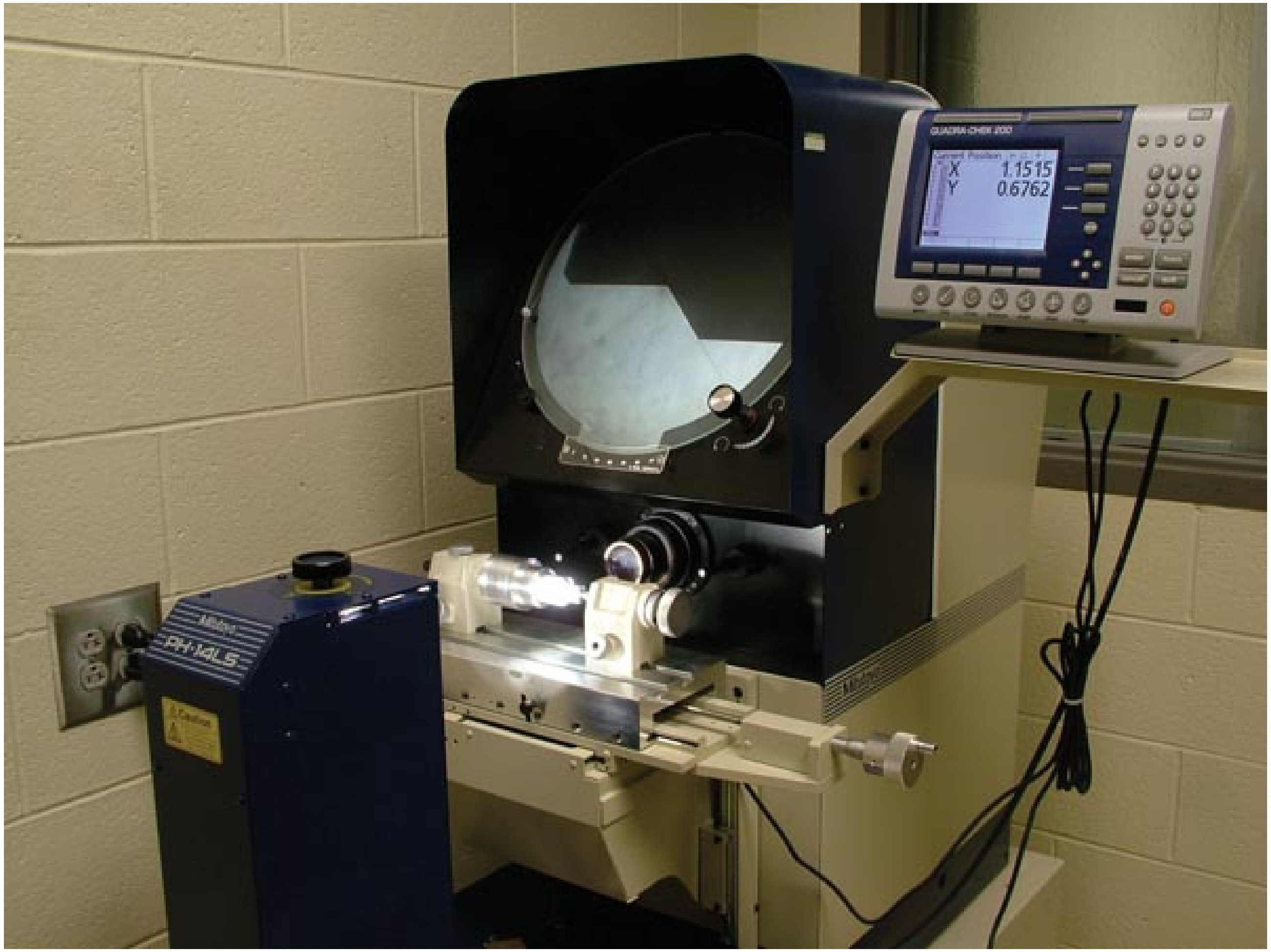


FIGURE 2.4.109 An optical comparator magnifies small parts and projects them on a screen for measurement. A digital readout measures dimensions as the table is moved.

Toolmaker's Microscope

- Use micrometer dials to measure
    - Can connect to cameras or computers

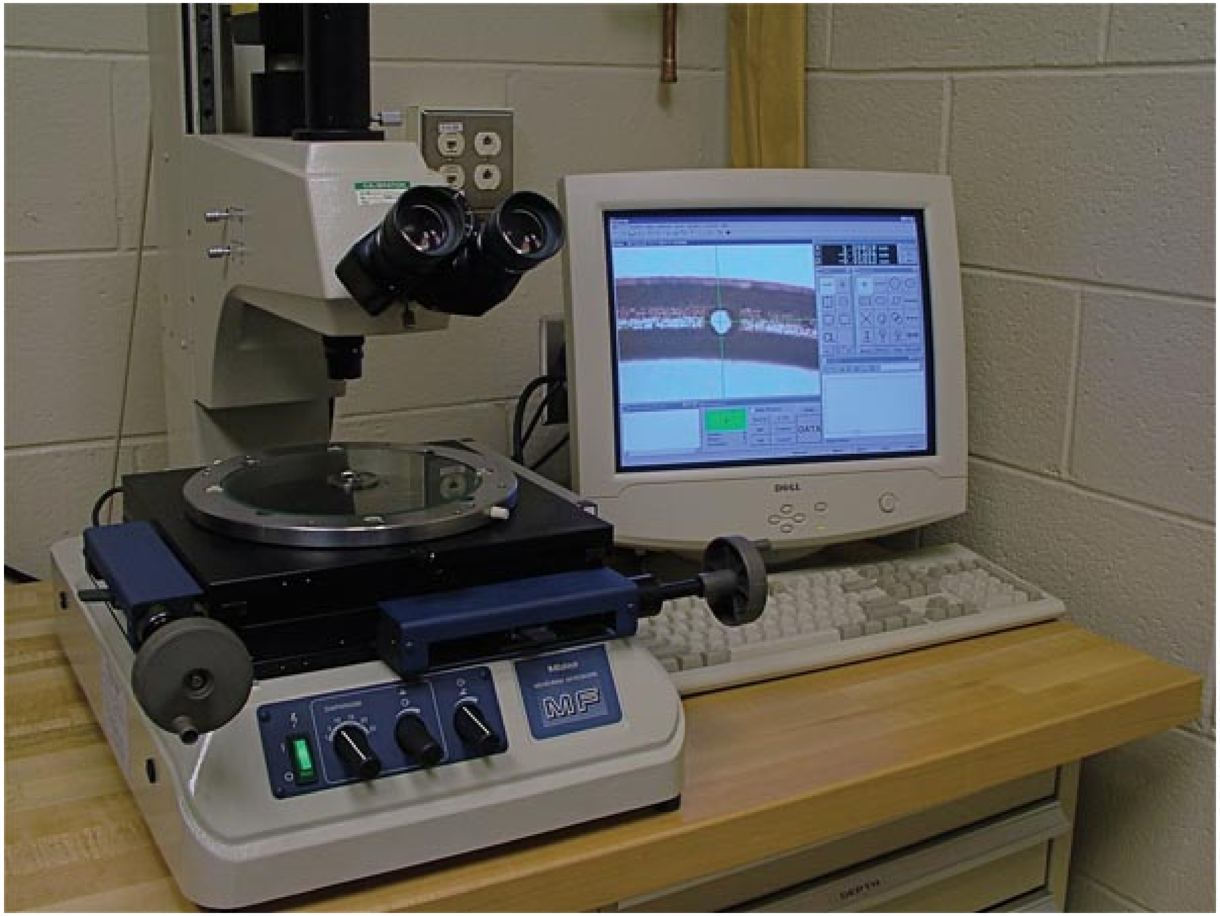


FIGURE 2.4.110 A toolmaker's microscope with video output for display on a computer.

Coordinate Measuring Machine (CMM)

- Identifies locations in an X, Y, Z coordinate system using an electronic probe

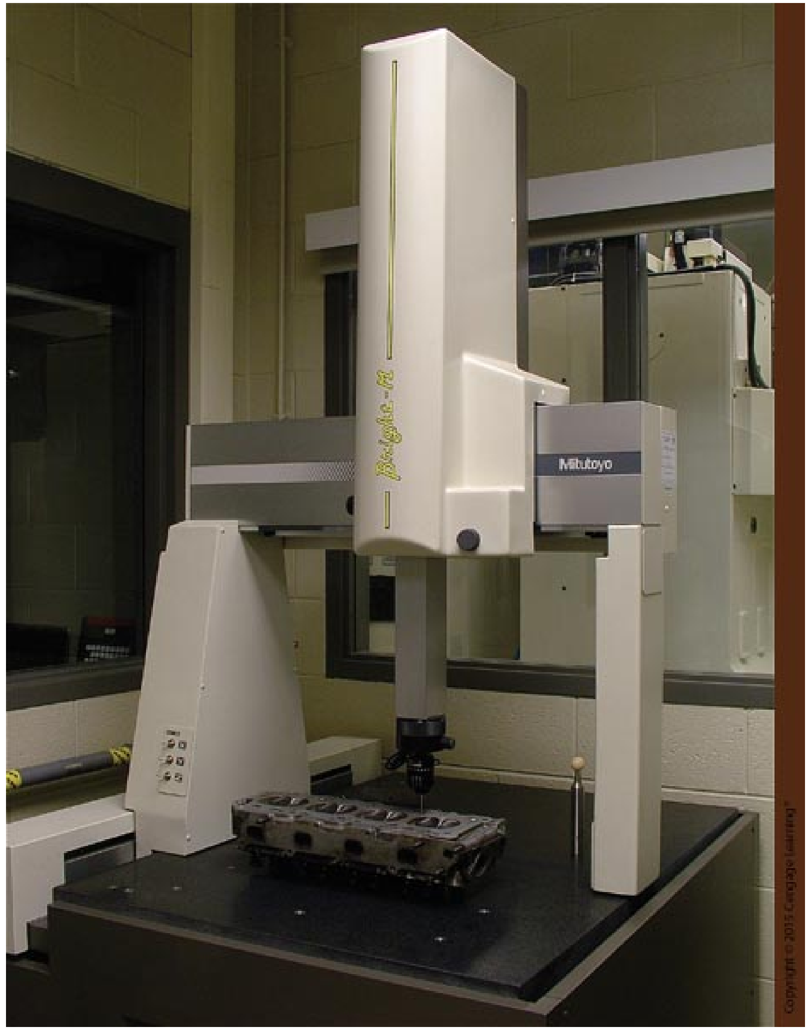


FIGURE 2.4.111 A coordinate measuring machine can inspect dimensions of complex parts like this engine cylinder head by moving the probe to touch part surfaces.

Gage Blocks

Gage Block Manufacture

- Rectangular blocks of hardened and ground alloy steel
- Stabilized through alternate cycles of extreme heat and cold
  - Crystalline structure of metal left without strain
- Two measuring surfaces lapped and polished to optically flat surface and to specific size
  - Accurate within range of 2 – 8 millionths of inch

Gage Block Manufacture

- Size of each block stamped on surface
- Great care exercised in manufacture
- Final calibration done where temperature maintained at 68 degrees F.
  - Therefore, only accurate to size when measured at this temperature
- Types: Chrome-plated, carbide (for long wear) and ceramic (zirconia)

Main Features of Zirconia Ceramic Gage Blocks

- Corrosion resistant
- No detrimental effects as a result of handling
- Superior abrasion resistance (10X steel)
- Thermal expansion coefficient close to steel
- Resistant to impact
- Free from burrs
- Wring together tightly

Gage Block Uses

- To check dimensional accuracy of fixed gages to determine extent of wear, growth, or shrinkage
- To calibrate adjustable gages
- To set comparators, dial indicators, and height gages to exact dimensions
- To set sine bars and sine plates when extreme accuracy required in angular setups

Gage Block Uses

- For precision layout with use of attachments
- To make machine tool setups
- To measure and inspect accuracy of finished parts

Inch Standard Gage Blocks

- Sets range from few blocks to as many as 115
- Most common is 83-piece set
  - Can make over 120,000 different measurements
- Two wear blocks supplied with set
  - Used as end of combination
  - Wear occurring during use will be on these only
  - Good practice to always expose same face of wear block to work surface
  - Prolongs life and accuracy of set

Metric Gage Blocks

- Supplied in sets of 47, 88, 113 blocks
- Most common is 88-piece set
- Each set contains pair of 2-mm wear blocks
  - Used at end of buildup to prolong accuracy of other blocks

Three Degrees of Accuracy

- Class AA (laboratory or master set)
  - Accurate to ±.000002 in. or ±0.00005 mm.
  - Used in temperature controlled labs as references
- Class A (inspection set)
  - Accurate to ±.000004 in.
    and +0.00015 mm. and -0.00005 mm.
  - Used for inspection purposes
- Class B (working set)
  - Accurate to ±.000008 in.
    and +0.00025mm. and -0.00015 mm.
  - Used in shop for setups, layouts and measurement

Effect of Temperature

- Changes important when handling
- Calibrated at 68 degrees F
  - Human body temperature 98 degrees F
- one degree F rise will cause a four inch stack of gage blocks to expand .000025 in.
  - Handle as little as possible!

Avoiding Temperature-Change Errors

- Handle only when they must be moved
- Hold by hand for as little time as possible
- Hold between the tips of fingers so that area of contact is small, or use insulated tweezers
- Have the work and gage blocks at the same temperature
- Where extreme accuracy is necessary, use insulating gloves and tweezers

Gage Blocks

- Manufactured to great accuracy
- Adhere to each other so well can withstand 200-pound pull (890-newton)
  - Atmospheric pressure
  - Molecular attraction
  - Extremely flat surfaces of blocks
  - Minute film of oil
  - Combination of all above

Example:
Measurement of 1.6428 in. required

Gage Block Buildups

- Clean blocks with clean, soft cloth
- Wipe each contacting surface on clean hand palm or on wrist
- Place end of one block over end of another block
- While applying pressure, slide one block over other

Note: If blocks do not adhere to each other, it is generally because blocks have not been thoroughly cleaned.

Care of Gage Blocks

- Keep in closed case to protect from dust and dirt
- Do not handle unnecessarily
- Avoid fingering lapped surfaces
- Do not drop or scratch their lapped surfaces

Care of Gage Blocks

- Immediately after use, each block should be cleaned, oiled, and replaced in the storage case
- Before wrung together, faces must be free from oil and dust
- Should never be left wrung together for any length of time

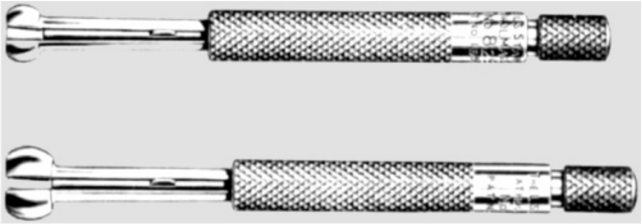
Inside-, Depth-, and Height-Measuring Instruments

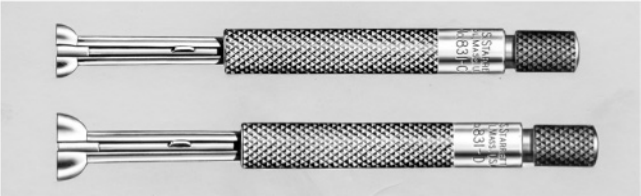
Intrimik

- Consists of head with three contact points spaced 120º apart attached to micrometer
- Contact points forced out to contact inside of hole
- Self-centering
- Provides direct reading
- Range: .275 to 12.000 in
- Accuracy: .0001 - .0005 in

Transfer-Type Instruments

- Size of object taken with instrument not capable of giving direct reading
- Small hole gages for small measures
  - Sets of four
  - Range: .125 - .500 in.



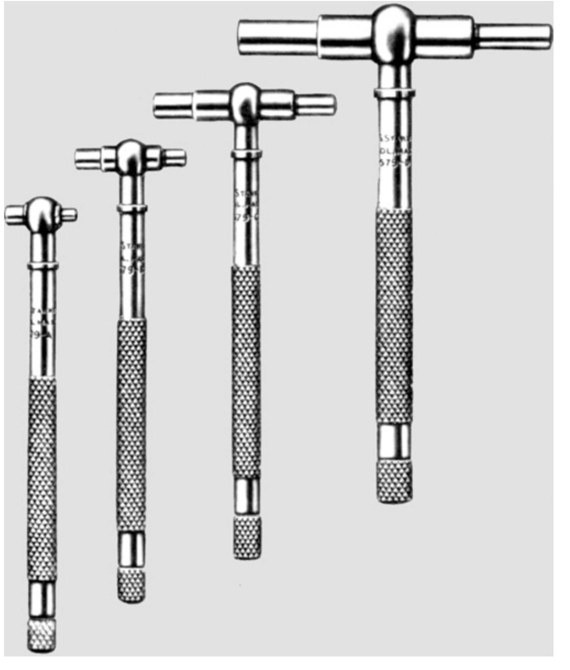


To Use Small Hole Gage

- Require extreme care in setting
  - Measure hole with rule
  - Select proper small hole gage
  - Clean hole and gage
  - Adjust gage slightly smaller than hole and insert
  - Adjust gage till touching sides of hole or slot
  - Swing handle back and forth ("feel") and adjust knurled end
  - Remove gage, check size with outside micrometer

Transfer-Type Instruments

- Telescope Gages
  - Used to obtain size of holes, slots, and recesses from .3125 to 6.000 in. (8 to 152 mm)
  - T-shaped: pair of telescoping tubes connected to handle
  - Knurled knob on handle end locks plungers into position



To Measure Using a Telescope Gage

- Measure hole size and select gage
- Clean gage and hole
- Depress plungers until smaller that hole
- Insert into hole, release plungers
- Lightly snug up knurled knob
- Hold bottom leg in position and move handle downward through center, move top leg from side to side
- Tighten knurled knob to lock plunger position
- Recheck "feel" on gage
- Check gage size with outside micrometers

Dial Bore Gages

- Used to check hole diameters and bores for size, out-of-round, taper, bellmouth, hourglass, or barrel shapes
- Gaging accomplished by three spring-loaded centralizing plungers in head
  - One actuates dial indicator
    - ten-thousands of inch or 0.01 mm graduations
- Six sizes cover range 3-12 in or 75-300 mm
- Extensions increase range

Micrometer Depth Gage

- Used for measuring depth of blind holes, slots, recesses, and projections
- Consists of flat base attached to micrometer sleeve
  - Extension rod of required length fits through sleeve and protrudes through base
    - Held in position by threaded cap on top of thimble
    - Come in various lengths up to 9.000 in. (225 mm)
  - Screw has range: .500 or 1.000 in (25mm)
- Available with either round or flat rods

To Measure with a Micrometer Depth Gage

- Remove burrs from edge of hole and face
- Clean work surface and base of micrometer
- Hold micrometer base against work surface
- Rotate thimble lightly until bottom of extension rod touches bottom of hole
- Recheck micrometer setting
- Carefully not reading

Numbers on thimble and sleeve are reverse of standard micrometer.

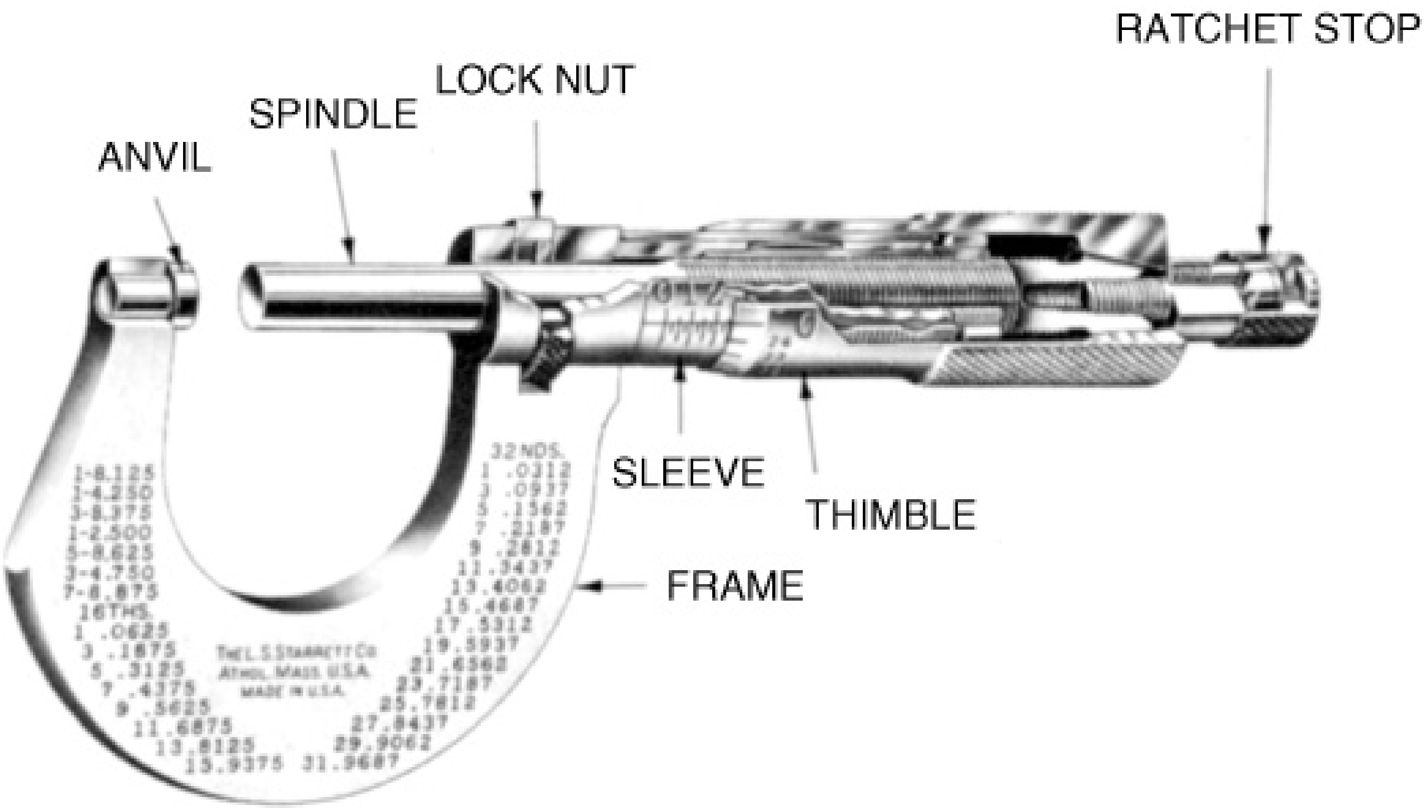
Micrometers

Precision Measuring Tools

- Five categories of tools based on the dimension being measured
  - Outside
  - Inside
  - Depth
  - Thread
  - Height

Micrometer Caliper

- Standard inch micrometer accurate to .001 in.



Principle of the Inch Micrometer

- Two important thread terms
  - Pitch
    - Distance from point on one thread to corresponding point on next thread
    - Inch threads pitch expressed as 1/N(Number of threads)
    - Metric threads expressed in millimeters
  - Lead
    - Distance screw thread advances axially in one complete revolution

Principle of the Inch Micrometer

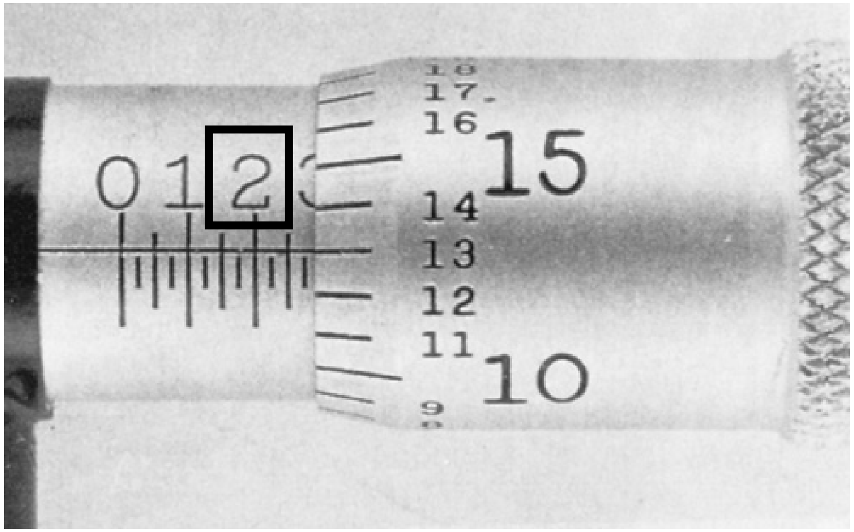
- Zero line on thimble lined up with index line on sleeve (barrel)
  - Measuring faces just touch
- Pitch is 1/40 (.025) in.since 40 threads
  - One complete revolution of spindle, one line appears
  - Every fourth line longer (represents .100 in.)
- Thimble has 25 equal divisions
  - Represents .001 in.

To Read Standard Inch Micrometer

- Note last number showing on sleeve and multiply by .100
- Note number of small lines visible to right and multiply by .025
- Note number of divisions on thimble from zero to line that coincides with index line on sleeve and multiply by .001
- Add three products to get total reading

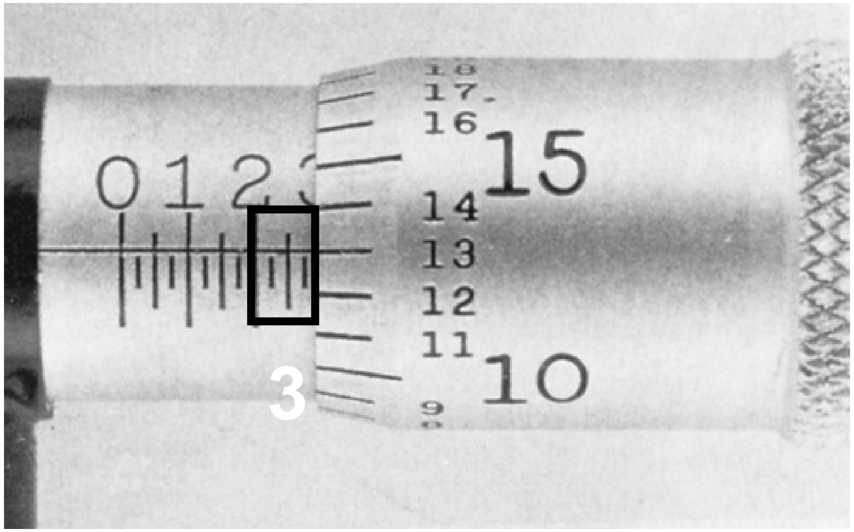
Sample Reading

- Note last number showing on sleeve and multiply by .100



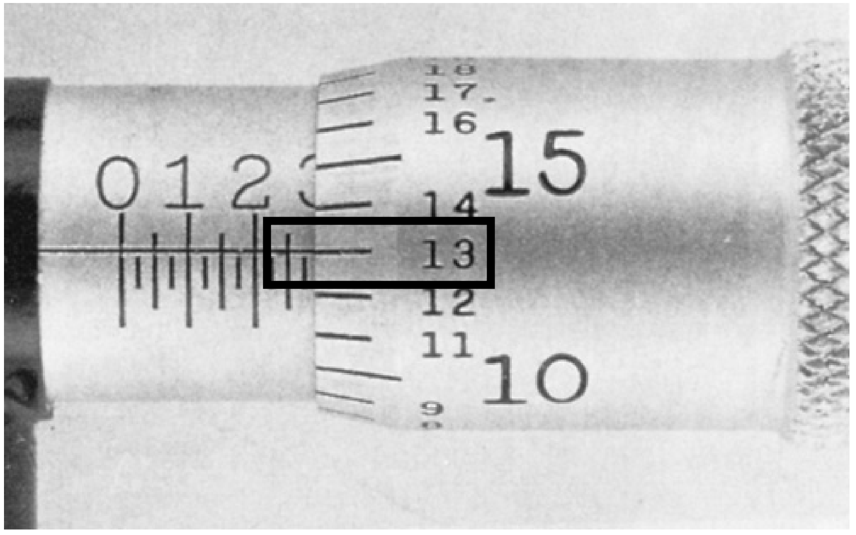
Sample Reading

- Note number of small lines visible to right and multiply by .025



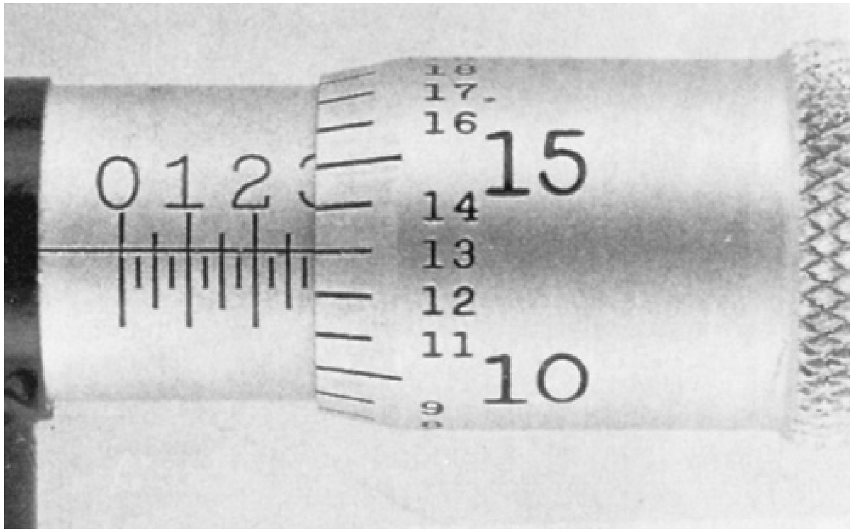
Sample Reading

- Note number of divisions on thimble from zero to line that coincides with index line on sleeve and multiply by .001

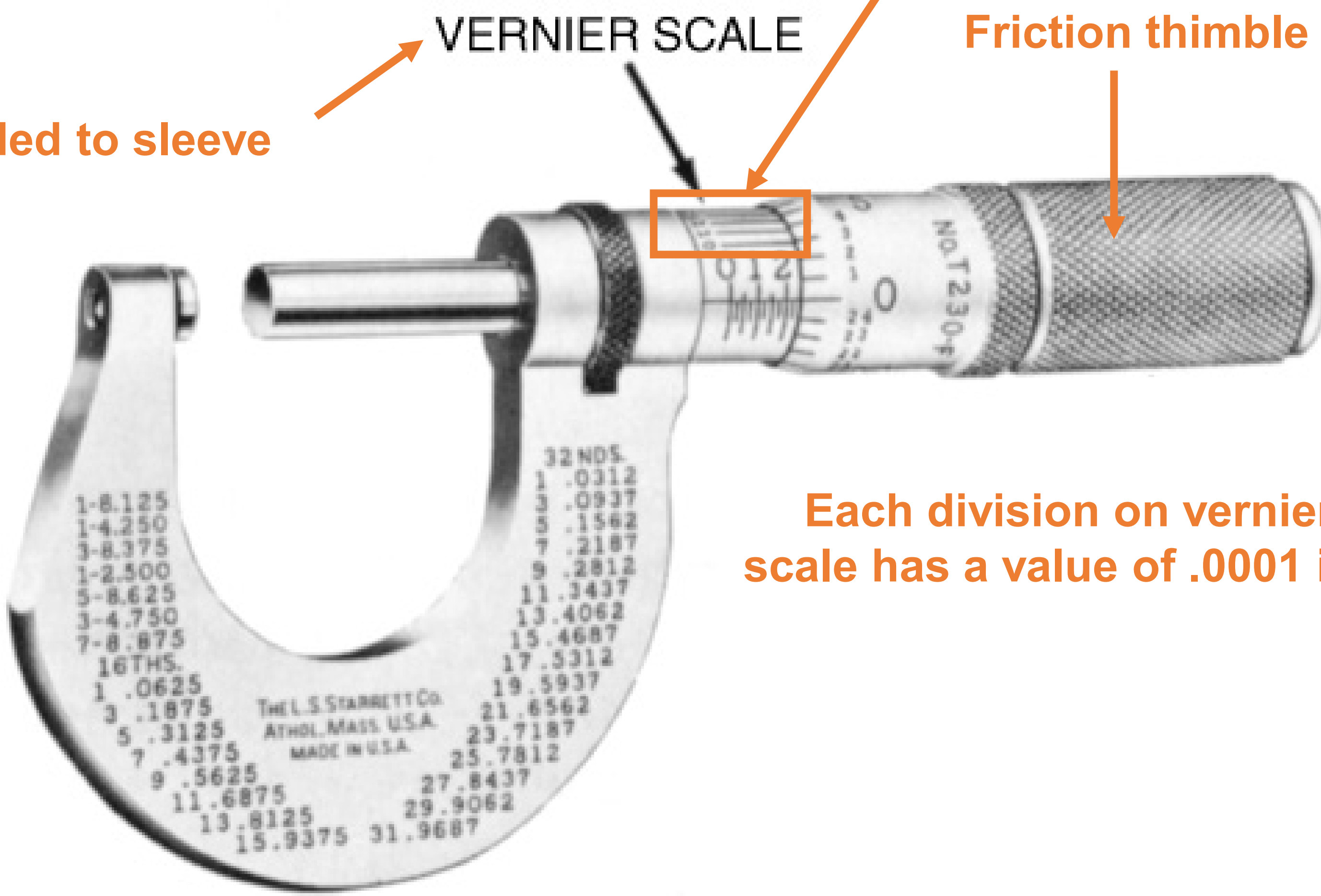


Sample Reading

- Add three products to get total reading



Vernier Micrometer



To Read Vernier Micrometer

- Read as would a standard micrometer
- Note line on vernier scale that coincides with one on thimble
  - Indicates number of ten-thousandths
  - Multiple the line number times .0001
- Add to total of the other readings

Metric Micrometer

- Similar to inch micrometer with two exceptions
  - Pitch of spindle screw (0.5 mm)
  - Graduations on sleeve and thimble
    - Above index line on sleeve, graduations in millimeters (from 0 to 25) with every fifth line numbered
    - Below index line, each millimeter subdivided into two equal parts of 0.5 mm
    - Thimble circumference in 50 equal divisions (0.01mm)

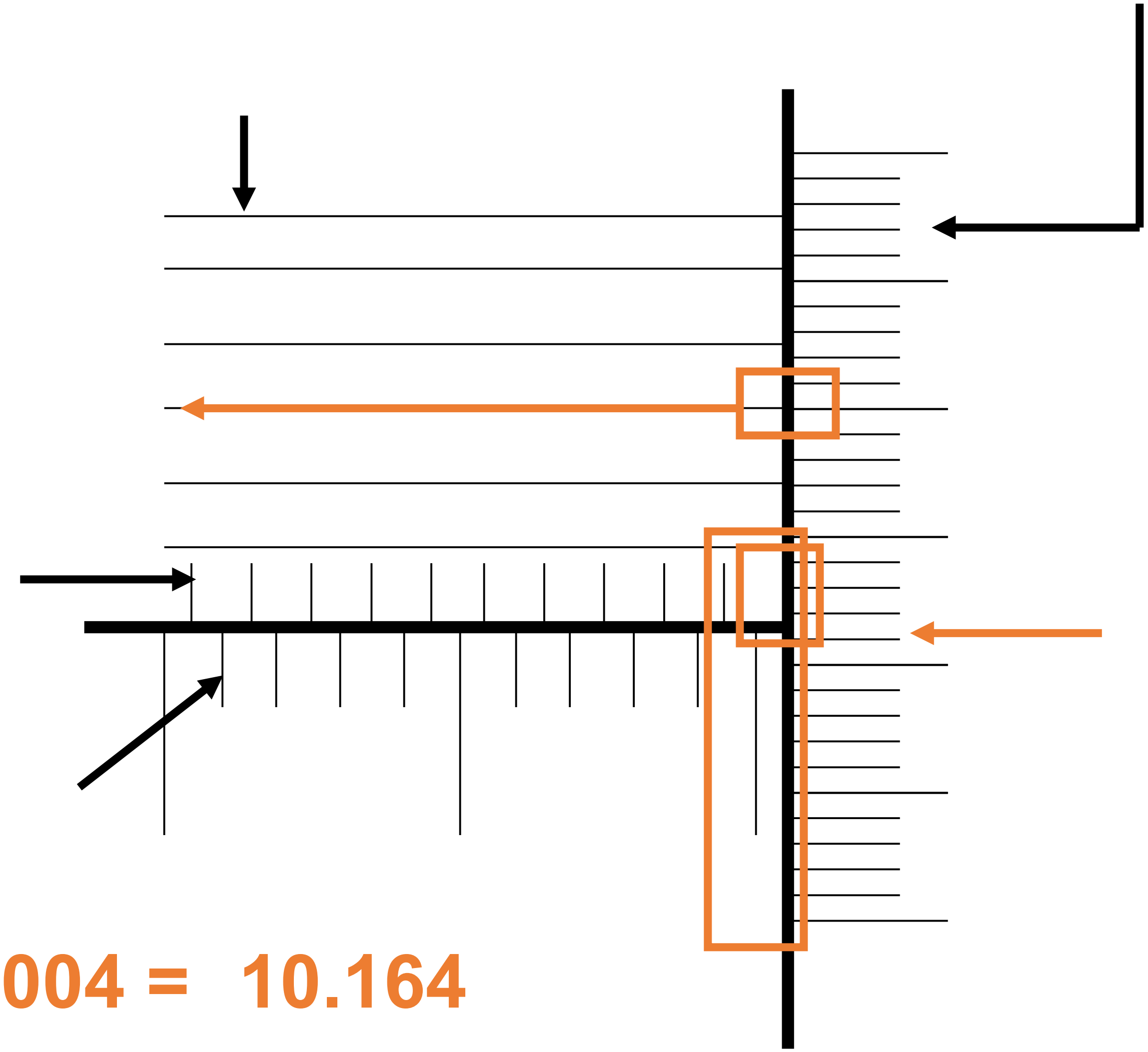
To Read Metric Micrometer

- Note number of last main division showing above line to left of thimble
- Multiply that number by 1 mm
- If there is half-millimeter line showing below index line, between whole millimeter and thimble, add 0.5 mm
- Multiply number of line on thimble that coincides with index line times 0.01
- Add these products

Metric Vernier Micrometer

- In addition to graduations on standard micrometer, has five vernier divisions on barrel (each = .002 mm)
- Major division below index line
  - Each = 1 mm
- Minor division above index line
  - Each = .5 mm
- Fifty divisions around thimble
  - Each =0.1 mm)

Metric Vernier Reading

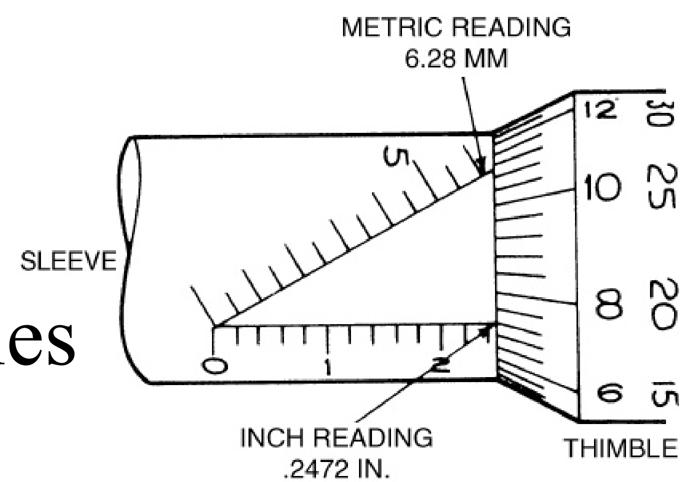


10 + 0 + .16 + .004 = 10.164

Combination Inch-Metric Micrometer

- Will give readings in both inch and metric
- Digital reading for one system, standard b
  and thimble reading for er

- Another type has dual scales on sleeve and thimble



Micrometer Adjustments:
Remove Play in Threads

- Back off the thimble
- Insert C-spanner into slot or hole of adjusting nut
- Turn adjusting nut clockwise until play between threads has been eliminated

Note: After adjusting, spindle should advance free while ratchet stop or friction thimble is being turne

Testing Accuracy of Micrometers

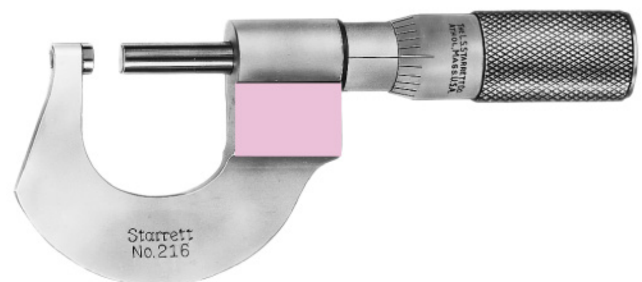
- Test periodically to ensure accuracy
- Clean measuring faces before testing
- Turn thimble using friction thimble or ratchet stop until measuring faces contact each other
  - Zero line on thimble coincides with center index line on sleeve = accuracy
- Can also check by measuring gage block or other known standard

Adjusting Accuracy of a Micrometer

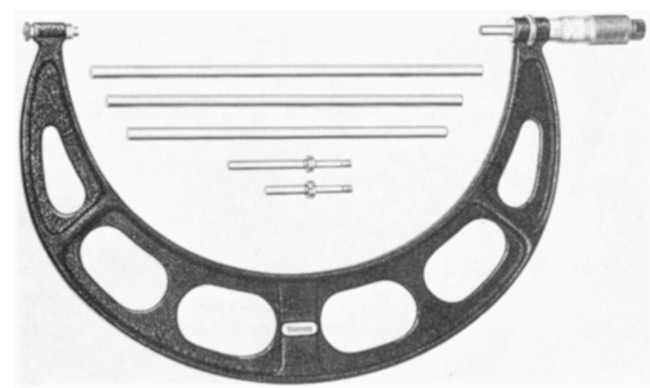
- Clean measuring faces; inspect for damage
- Close measuring faces carefully by turning ratchet stop or friction thimble
- Insert C-spanner into hole or slot in sleeve
- Carefully turn sleeve until index line on sleeve coincides with zero line on thimble
- Recheck accuracy

Special-Purpose Micrometers

- Direct-reading micrometer
  - Additional digital readout built into frame

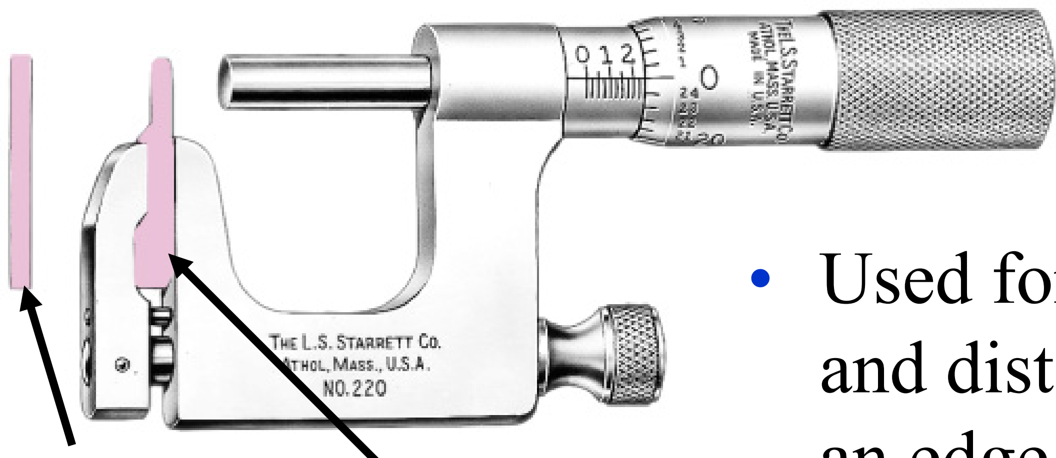


- Large-frame micrometer
  - Made for measuring large outside diameters up to 60 in.
  - Interchangeable anvils give range of 6 in.



Other Micrometers

- Indicating micrometer
  - Uses indicating dial and movable anvil
  - Accurate to ten-thousandths of an inch
  - Can be used as a comparator with gage blocks



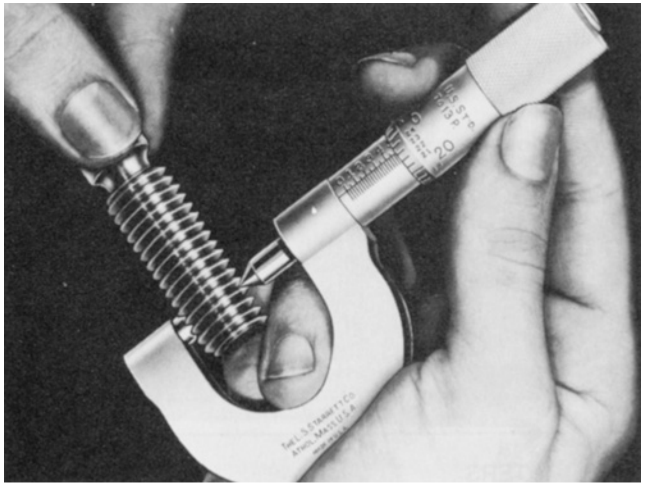
- Mul-T-Anvil micrometer
- Used for measuring tubing and distances from a slot to an edge

Digi-Matic Micrometer

- Used as hand gage for inspecting small parts
- Accurate up to 50 millionths of an inch and displays both inch or metric sizes
- Statistical process control when added provides stand-alone inspection system
    - Interface with PC

Screw Thread Micrometers

- Measures pitch diameter of threads
- Pointed spindle and double-V swivel anvil
  - Shaped to contact pitch diameter of thread
    - Equal to outside diameter less depth of one thread
- Limited to certain range
  - Four ranges for one-inch
    - 8-13 TPI
    - 14-20 TPI
    - 22-30 TPI
    - 32-40 TPI



Screw Thread Micrometers

- Ranges stamped on micrometer frame
- Metric available also in ranges
  - 0-25 mm
  - 25-50 mm
  - 50-75 mm
  - 75-100 mm
- Helix angle of thread can give slightly distorted reading
  - First set thread micrometer to thread plug gage

How to Measure With a Screw Thread Micrometer

- Select correct range micrometer
- Clean measuring surfaces and thread
- Check micrometer for accuracy
- Set micrometer to thread plug gage and note
- Fit swivel anvil onto threaded workpiece
- Adjust spindle until point just bears against opposite side of thread
- Carefully roll micrometer over thread to get proper "feel"
- Note readings and compare to thread plug gage