ME-215 MANUFACTURING MATERIALS & PROCESSES

- DeGarmo, Black, Kosher, “Materials and Processes in Manufacturing”, Wiley, 2008
- “Unit Manufacturing Processes”, National Academy Press, 1995
- www.

COURSE OBJECTIVES

To learn

- Materials used
- Physical phenomena used
- A complex manufacturing technologies
- A new manufacturing technologies
- A rapid technologies change

CHALLENGES

- Large number
- Complexity
- Rapid change

APPROACH

- Knowledge of fundamentals
- Ability to use various sources of the knowledge, e.g. Internet

MANUFACTURING PROCESSES RESULT IN CHANGES OF

- Chemical composition
- Phase composition
- Structure
- Shape
- Mass
- Density

Measurement and Inspection and Testing

DEFINITIONS

- Measurement
  - Act of measuring or being measured
  - Fundamental activity of testing and inspection
- Inspection
  - Ensures what is being manufactured will meet specifications
- Testing
  - Evaluates product quality or performance

Attributes vs. Variables

- Inspection of a product can be done in two main ways
  - Attributes (Gaging)
    - Uses gages
    - Reported as YES/NO, GO/NO GO
  - Variables (Measurements)
    - Uses calibrated instruments
    - Reported in actual dimensions

Metric to English Conversions

- Table 10-2 lists common metric to English conversions
- Care should be taken when converting measurements to ensure that standard conversions have been used
- Standard sizes in the English system may not have a perfectly matching corresponding size in the metric system

Measuring Instruments

- Manually operated instruments
  - Ease of use, precision, accuracy are affected by:
    - Least count of subdivisions
    - Line matching
    - Parallax
  - Linear measuring instruments
    - Direct
      - Line graduated so that the measurement can be read right off of the scale
    - Indirect
      - Transfers the size of the dimension to a direct reading scale

Linear Measuring Devices

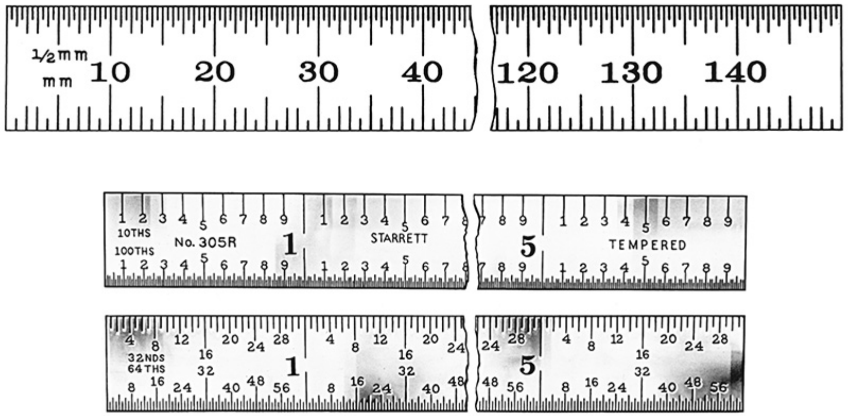
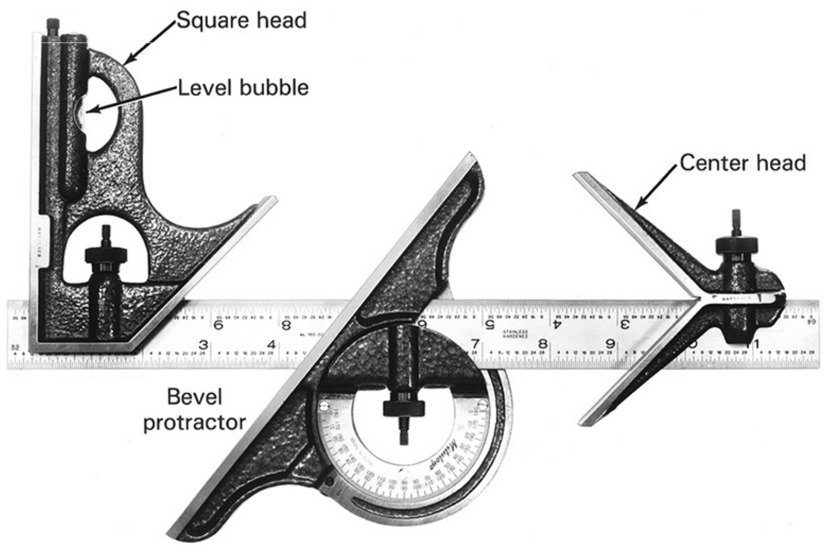
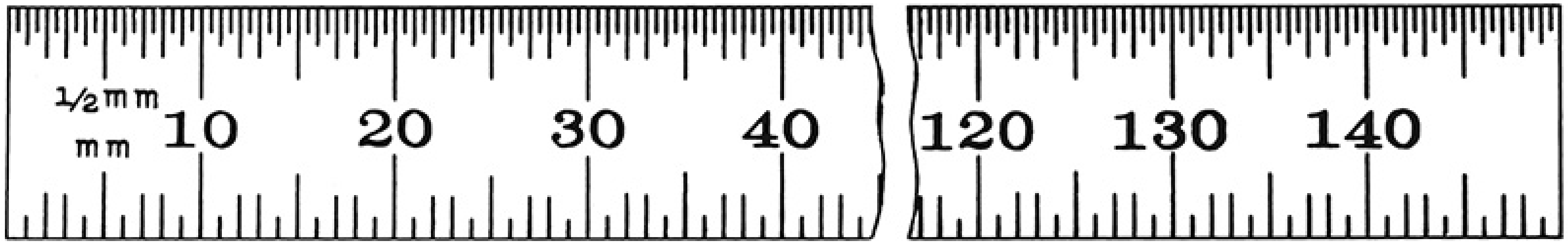
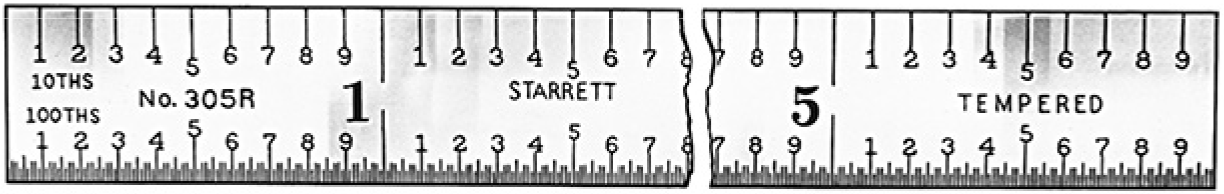


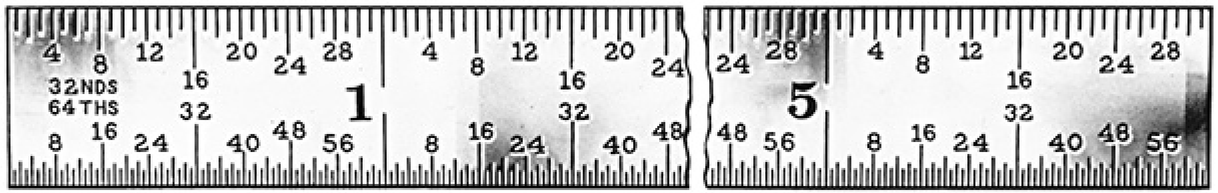
Figure 10-13 (above) Machinist's rules: (a) metric and (b) inch graduations; 10ths and 100ths on one side; 32nds and 64ths on the opposite side. (*Courtesy of L.S. Starrett Company*.)

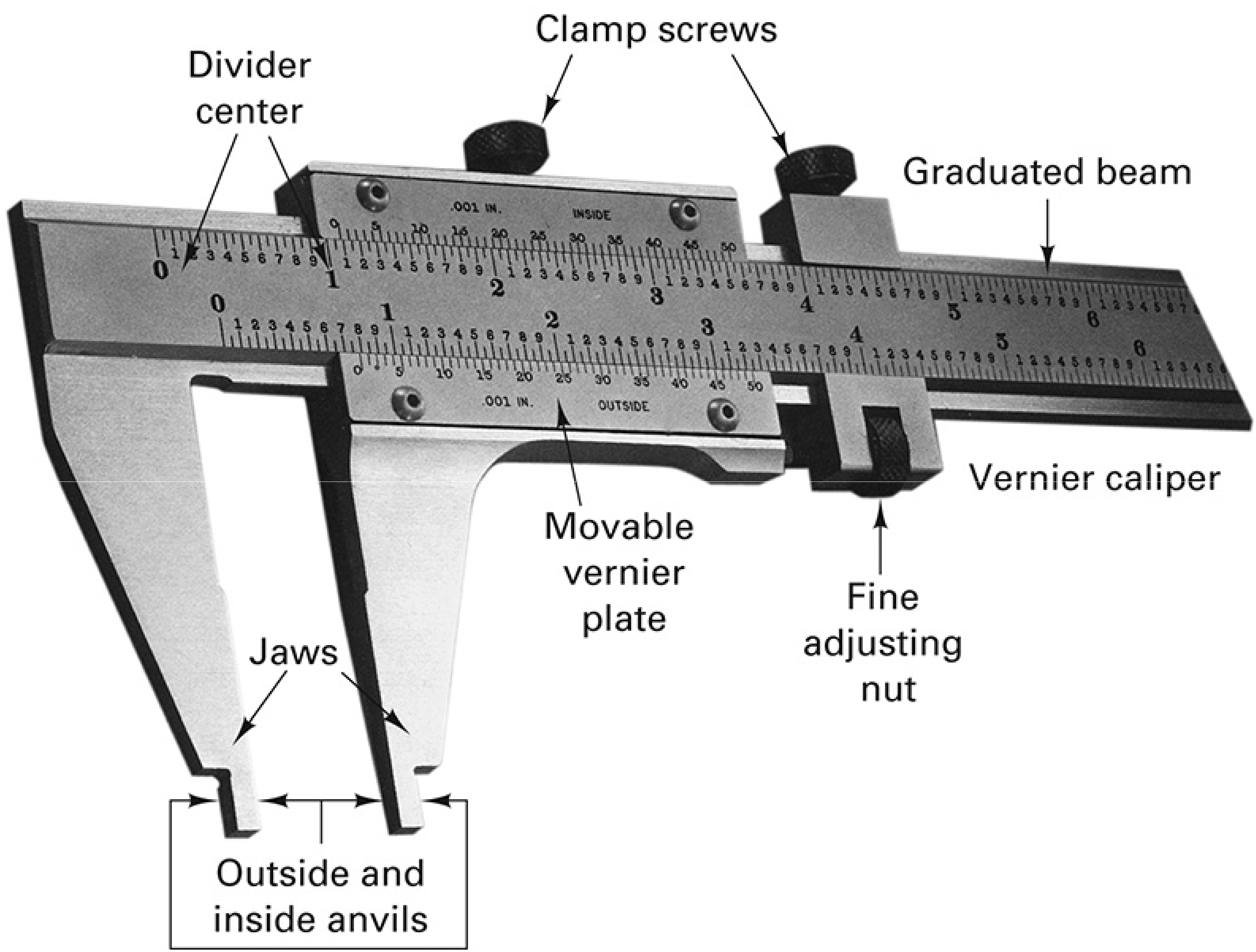
Figure 10-14 (below) Combination set. (*Courtesy of MTI Corporation.)*

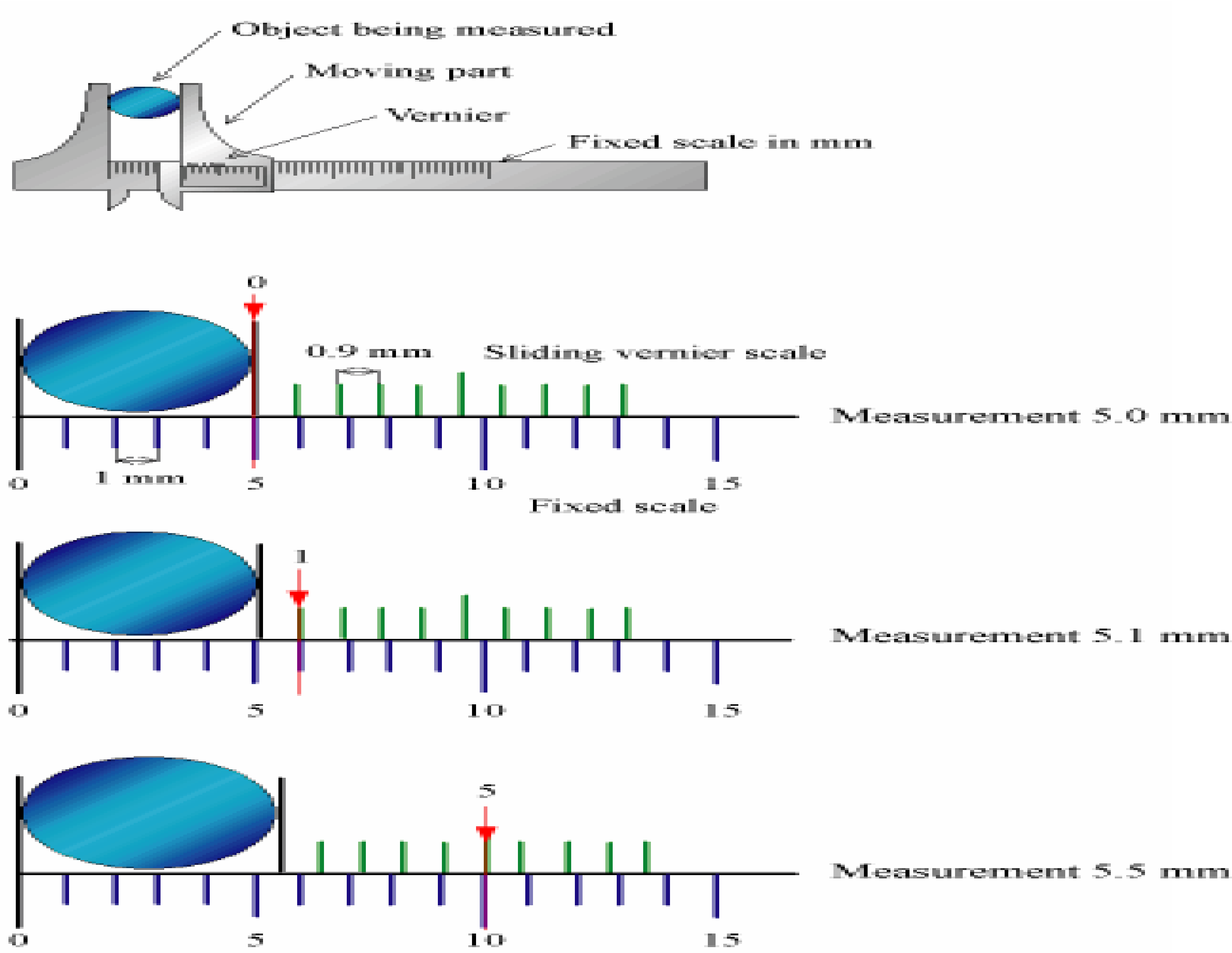



1/2 mm
mm
10
20
30
40
120
130
140


10THS
100THS
No. 305R
1
STARRETT
5
TEMPERED


32NDS
64THS
1
5

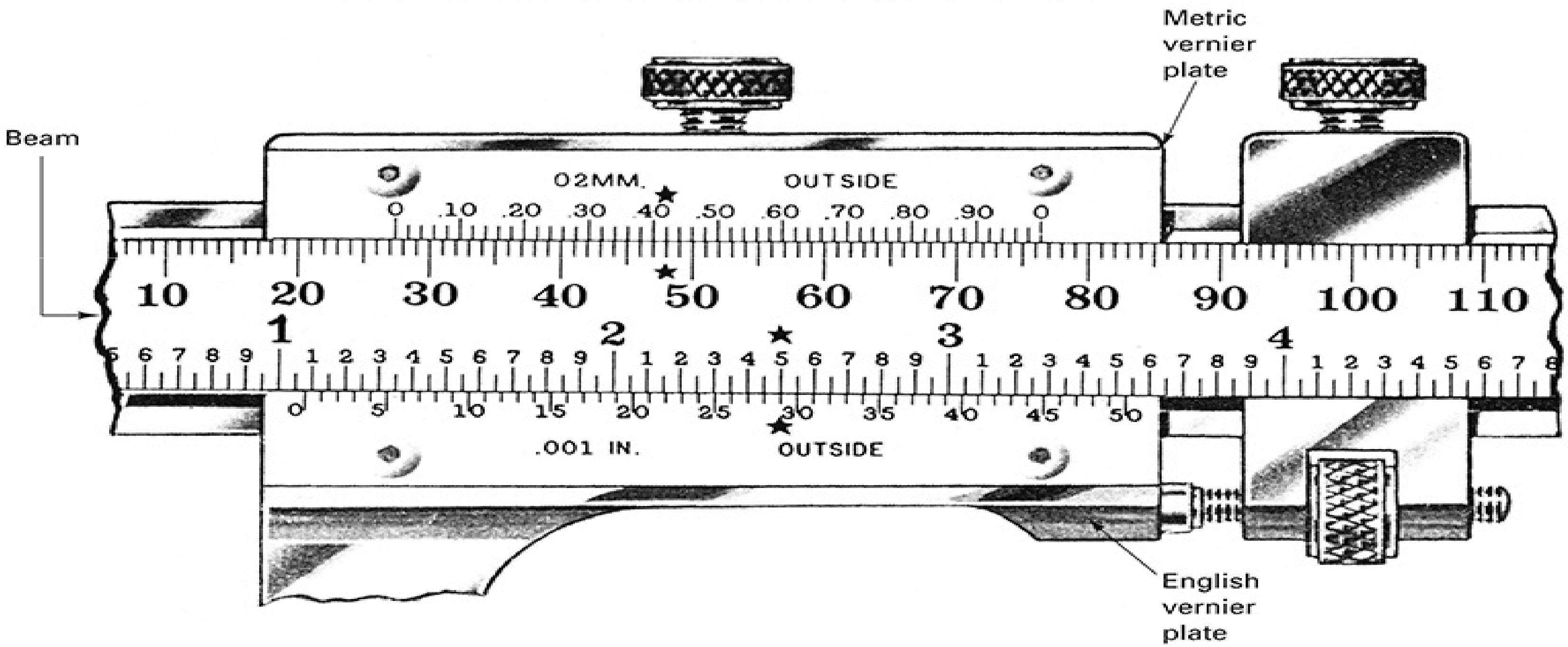

Clamp screws
Divider center
Graduated beam
Vernier caliper
Movable vernier plate
Fine adjusting nut
Jaws
Outside and inside anvils
.001 IN.
INSIDE
.001 IN.
OUTSIDE


Object being measured
Moving part
Vernier
Fixed scale in mm
0
0.9 mm
Sliding vernier scale
Measurement 5.0 mm
0
1 mm
5
10
15
Fixed scale
1
Measurement 5.1 mm
0
5
10
15
5
Measurement 5.5 mm
0
5
10
15

- The vernier scale is constructed so that it is spaced at a constant fraction of the fixed main scale. So for a decimal measuring device each mark on the vernier would be spaced nine tenths of those on the main scale. If you put the two scales together with zero points aligned then the first mark on the vernier scale will be one tenth short of the first main scale mark, the second two tenths short and so on up to the ninth mark which would be misaligned by nine tenths. Only when a full ten marks have been counted would there be an alignment because the tenth mark would be ten tenths, that is a whole main scale unit, short and will therefore align with the ninth mark on the main scale.

- Now if you move the vernier by a small amount, say, one tenth of its fixed main scale, the only pair of marks which come into alignment will be the first pair since these were the only ones originally misaligned by one tenth. If we had moved it 2 tenths then the second pair and only the second would be in alignment since these are the only ones which were originally misaligned by that amount. If we had moved it 5 tenths then the fifth pair and only the fifth would be in alignment. And so on for any movement, only one pair of marks will be in alignment and that pair will show what is the value of the small displacement.

Refer to the upper bar graduations and metric vernier plate.
Each bar graduation is 1.00 mm. Every tenth graduation is numbered in sequence—10 mm, 20 mm, 30 mm, 40 mm, etc.—over the full range of the bar. This provides for direct reading in millimeters.



In the picture, the vernier plate zero line is one inch (1.000") plus one-twentieth (0.50") beyond the zero line on the bar, or 1.050". The 29th graduation on the vernier plate coincides with a line on the bar (as indicated by stars). 29 × 0.001 (.029") is therefore added to the 1.050" bar reading, and the total is 1.079".

THE VERNIER SCALE (MM)

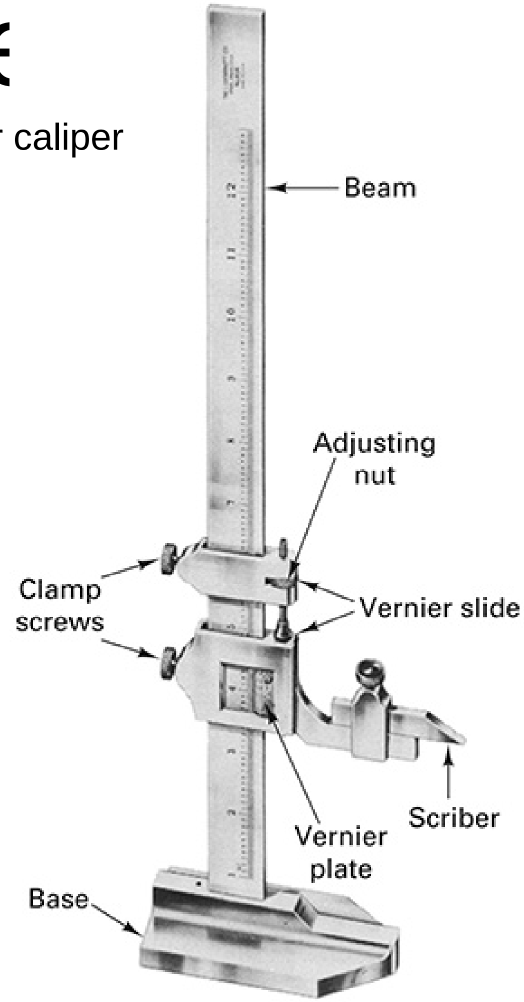
- I unit-1mm
- Number of marks on the vernier-50
- The accuracy-1mm/50=0.02 mm

THE VERNIER SCALE (in)

- I unit-0.05”
- Number of marks on the vernier scale-50
- The accuracy-0.05/50=0.001”

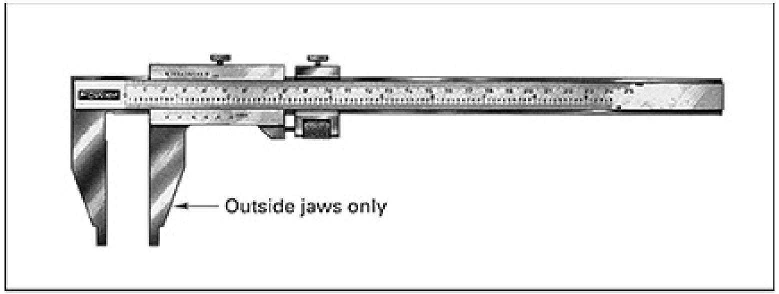
Vernier Calipe

Figure 10-17 (right) Variations in the vernier caliper design result in other basic gages.

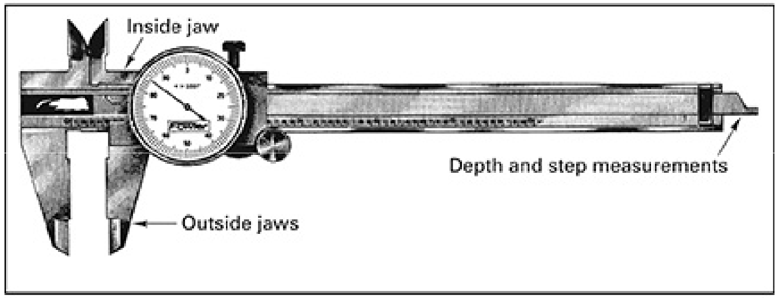


Vernier height gage

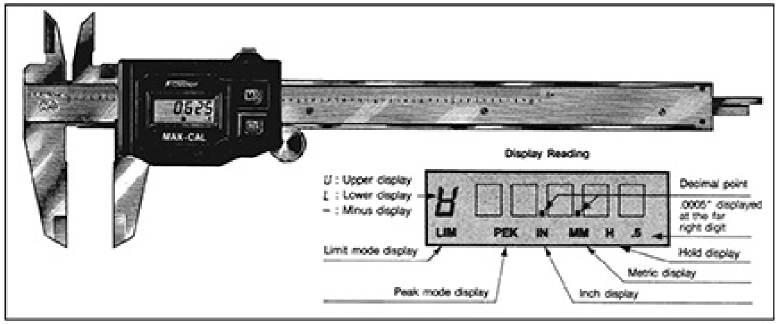
Other Forms of Calipers



Vernier caliper with inch or metric scales and 0.001-in. accuracy



Dial caliper with 0.001-in. accuracy

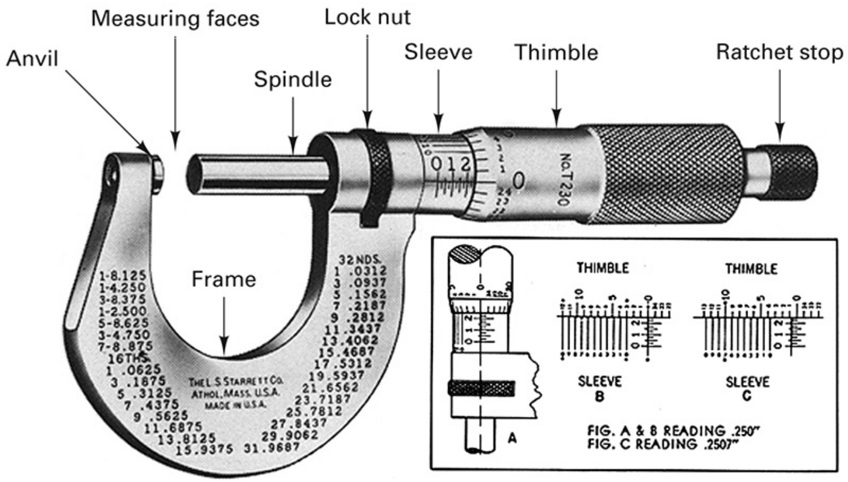


Digital electronic caliper with 0.001-in. (0.03-mm) accuracy and 0.0001-in. resolution with inch/metric conversion.

Figure 10-18 Three styles of calipers in common use today: (a) Vernier caliper with inch or metric scales and 0.001-in. accuracy; (b) dial caliper with 0.001-in accuracy; (c) digital electronic caliper with 0.001-in. (0.03-mm) accuracy and 0.0001-in resolution with inch/metric conversion.

Graduated and Digital Micrometers

Figure 10-19 Micrometer caliper graduated in ten-thousandths of an inch with insets A, B, and C showing two example readings. (*Courtesy Starrett Bulletin No. 1203.)*



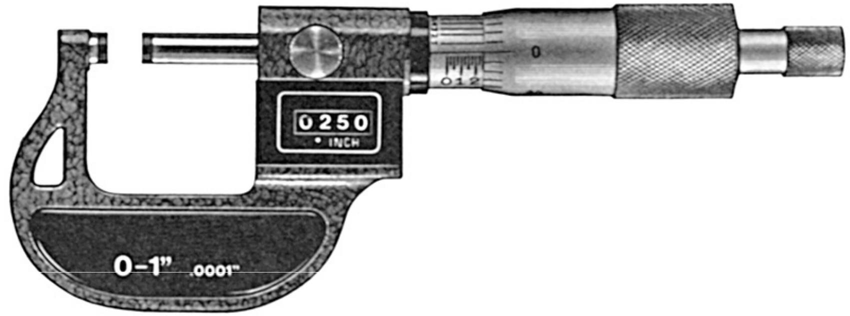


Figure 10-20 Digital micrometer for measurements from 0 to 1 in., in 0.0001-in. graduations.

MICROMETER

10.8 Angle Measurements

- Angle measurements are more difficult than linear measurements
- Variety of instrumentation can be used

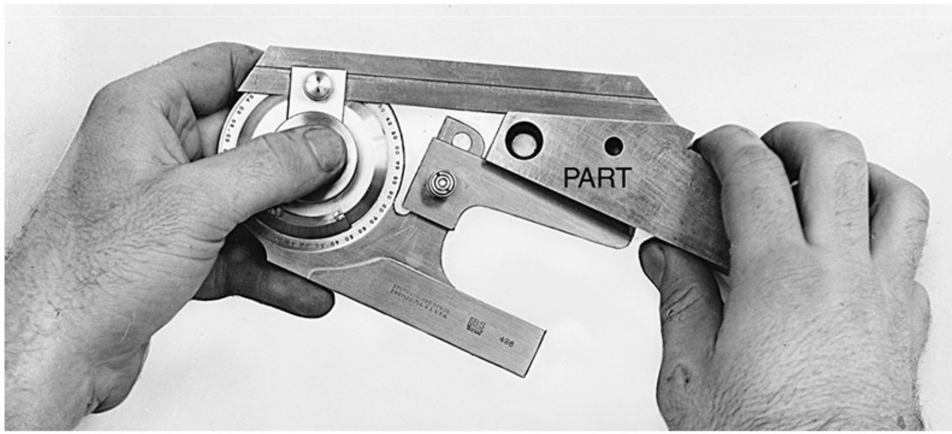


Figure 10-32 Measuring an angle on a part with a bevel protractor. (*Courtesy of Brown & Sharpe Mfg. Co.)*

Angle Measurements

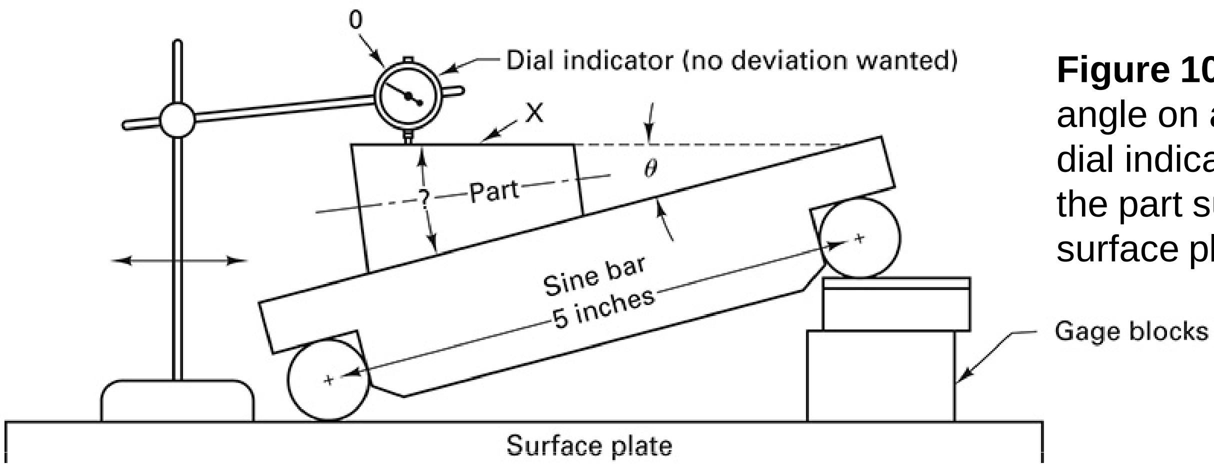


Figure 10-33 Setup to measure an angle on a part using a sine bar. The dial indicator is used to determine when the part surface X is parallel to the surface plate.

- Toolmaker's microscope can be used to make angle measurements
- Sine bar
- Angle gage blocks

Optical Instrumentation

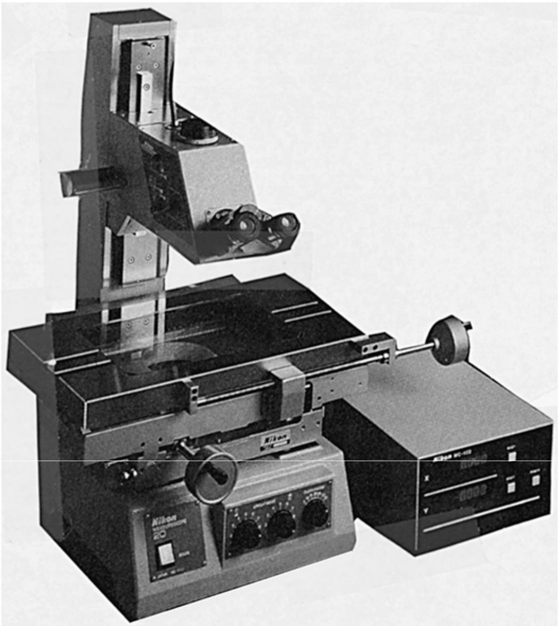
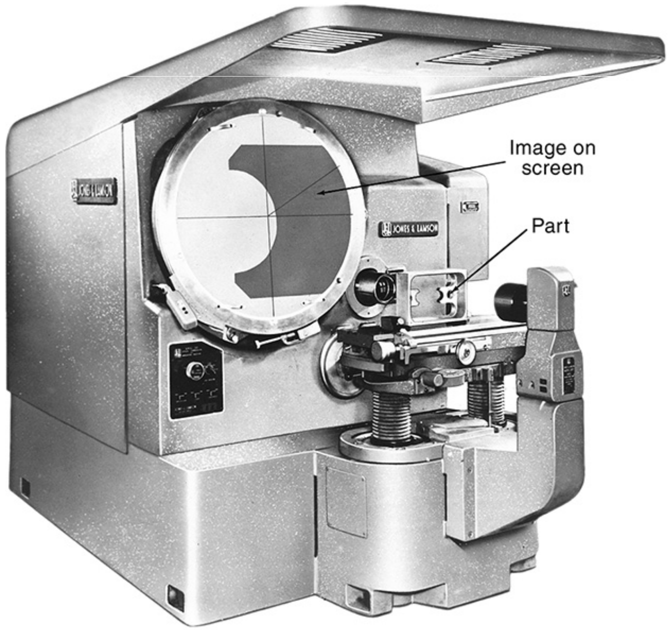


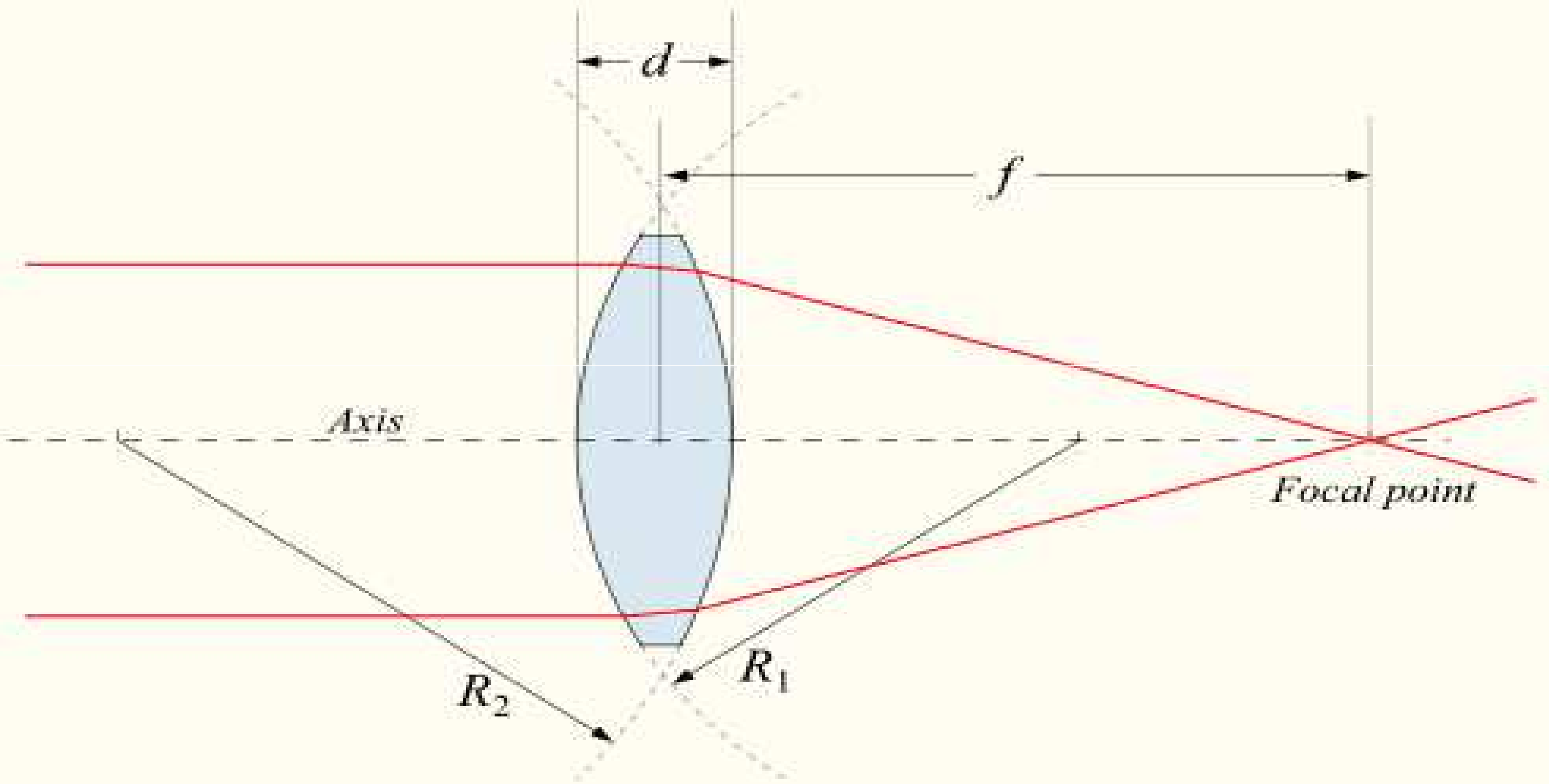
Figure 10-22 Toolmaker's microscope with digital readouts for *X* and *Y* table movements.

Figure 10-23 Optical comparator, measuring the contour on a workpiece. Digital indicators with conversions add to the utility of optical comparators.

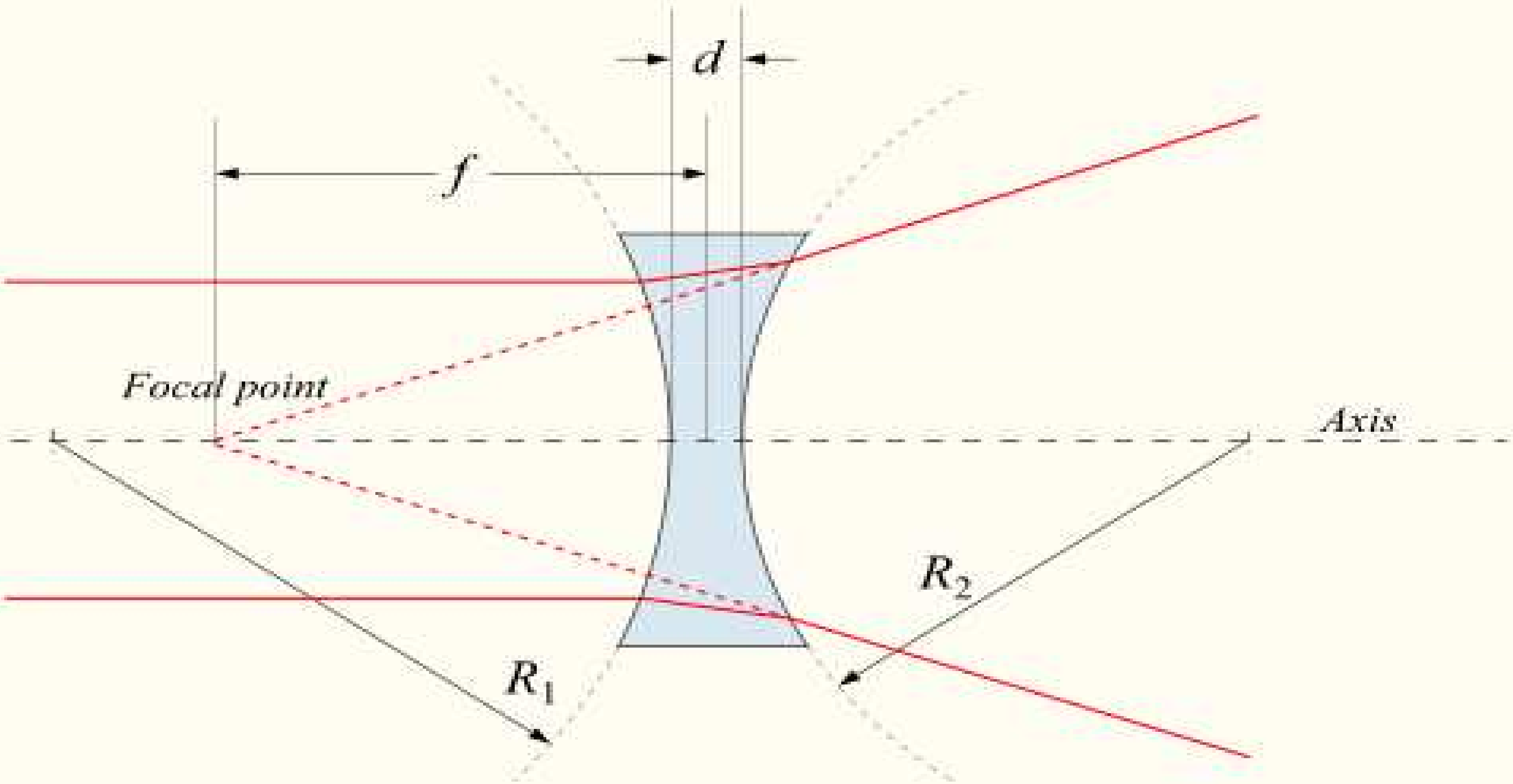



1
2
3
4
5
6
7
8
9

- ocular lens, or eyepiece
- objective turret
- objective lenses
- coarse adjustment knob
- fine adjustment knob
- object holder or stage
- mirror or light (illuminator)
- diaphragm and condenser



Positive (converging) lens



Negative (diverging) lens

10.7 Coordinate Measuring Machines

- Precise, three-dimensional measurements
- Measurements are made in the x, y, and z directions
- Computer routines can give the best fit to the feature

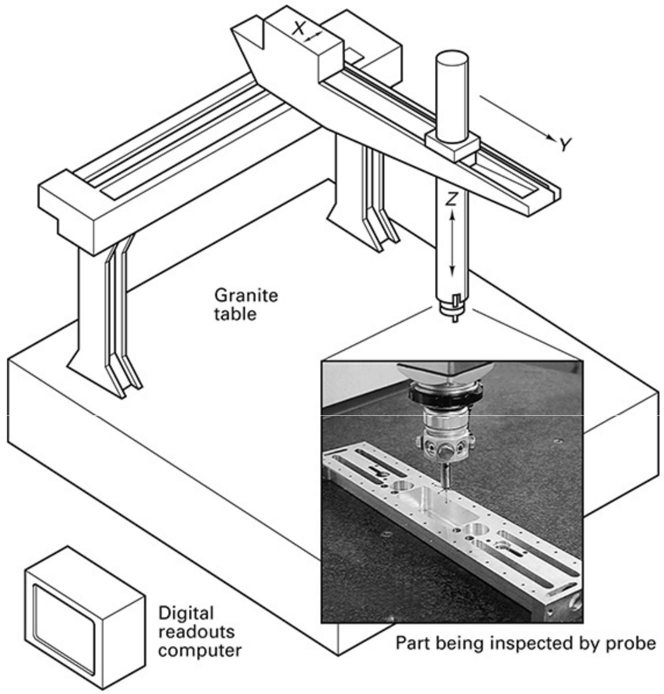
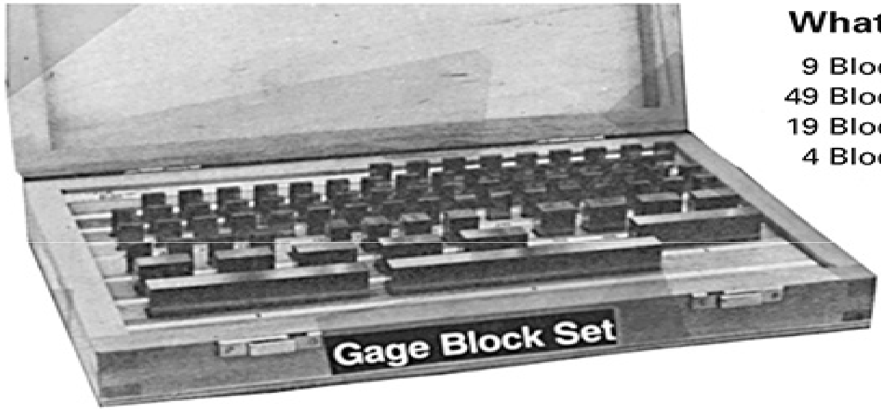


Figure 10-30 Coordinate measuring machine with inset showing probe and a part being measured.

10.9 Gages for Attributes Measuring

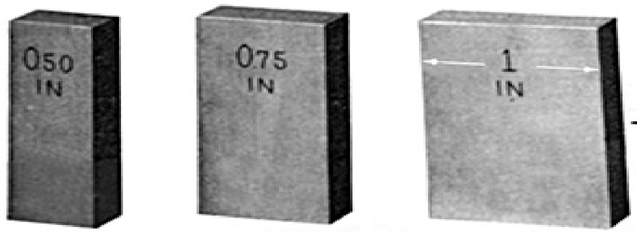
- It is not always necessary to know exact dimensions
- Attribute-type instruments are called gages
- Fixed-type gages
  - Gage only one dimension and indicate whether it is larger or smaller than some standard
  - Plug gage, go/no go gage, step-type gage, snap gage, ring gage

RECTANGULAR GAGE BLOCKS

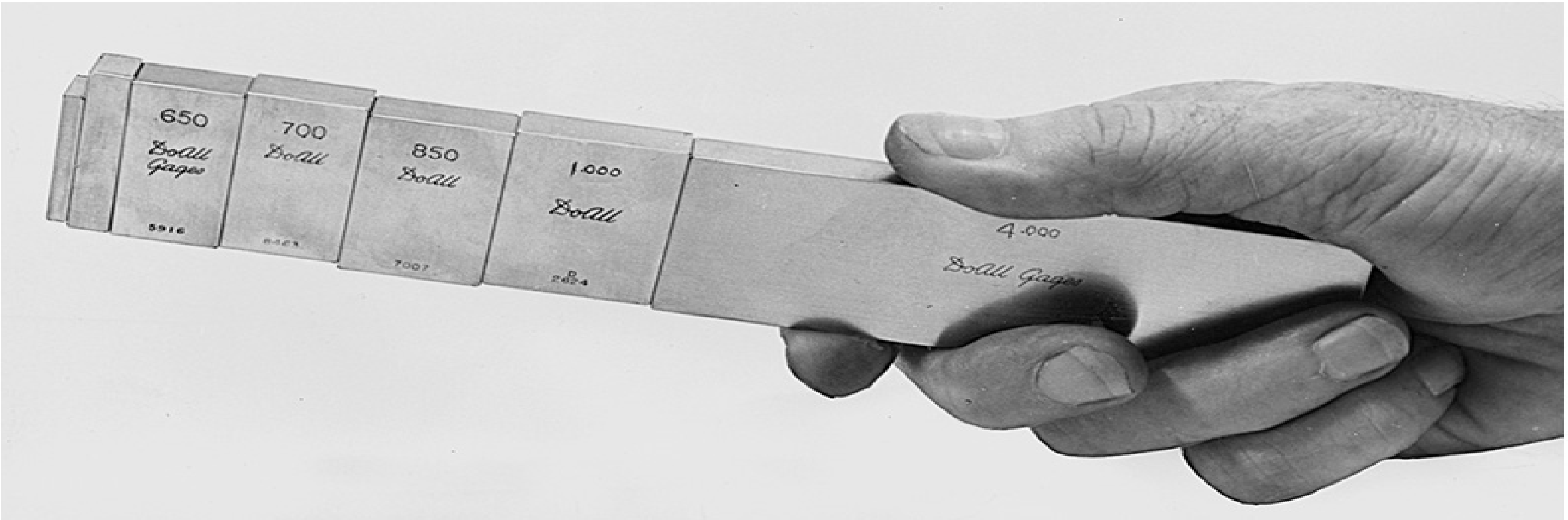


What's in the box

9 Blocks	0.1001	through 0.1009 in.	in steps of 0.0001 in.
49 Blocks	0.101	through 0.149 in.	in steps of 0.001 in.
19 Blocks	0.050	through 0.950 in.	in steps of 0.050 in.
4 Blocks	1.000	through 4.000 in.	in steps of 1.000 in.



GAGE BLOCK


650
DoAll Gages
700
DoAll
850
DoAll
1.000
DoAll
4.000
DoAll Gages

Length Standards in Industry

- Gage blocks
  - Provide industry with linear standards of high accuracy
  - Small, rectangular, square, or round in cross section
  - Made with steel or carbide
  - Two flat and parallel surfaces
  - calibrated with light-beam interferometry
  - By combining blocks,

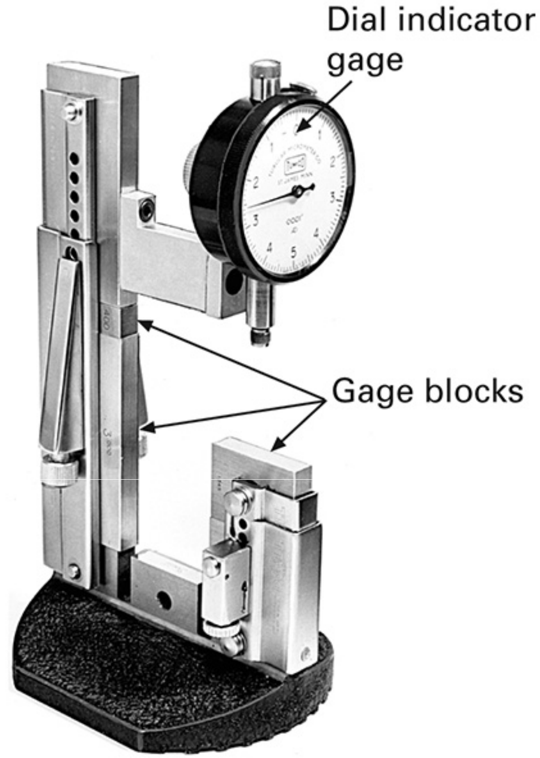


Figure 10-5 Wrung-together gage blocks in a special holder, used with a dial gage to form an accurate comparator. (Courtesy of DoALL Company.)

Fixed-Type Gages

Figure 10-36 Go and no-go (on right) ring gages for checking a shaft. (*Courtesy of Automation and Measurement Division, Bendix Corporation.)*

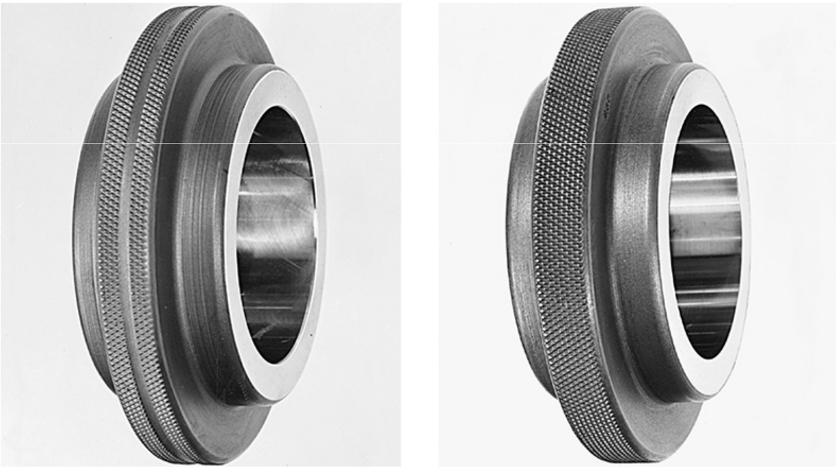
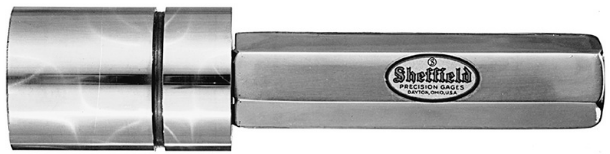


Figure 10-34 Plain plug gage having the go member on the left end (1.1250-in. diameter) and no-go member on the right end. (*Courtesy of Sheffield*.)

Figure 10-35 Step-type plug gage with go-no go elements on the same end. (*Courtesy of Sheffield.)*



Deviation-Type Gages

- Determines the amount by which a measured part differs from standard dimension
- Dial indicators
- Linear variable-differential transformers (LVDT)
- Air gages

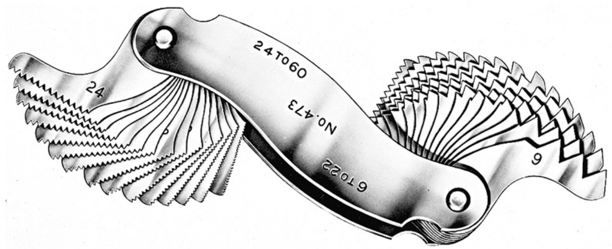


Figure 10-40 Thread pitch gages. (*Courtesy of L.S. Starrett Company.)*

Figure 10-41 Digital dial indicators with 1-in. range and 0.0001-in. accuracy. (*Courtesy of CDI.)*

Standard Measuring Temperature

- Many metal instruments are used for measuring
- Metals are affected dimensionally by temperature
- Standard measuring temperature of 68°F (20°C) for precision measuring
- Gage blocks, gages, and other precision-measuring instruments are calibrated at this temperature